# STUDIES ON THE TAXONOMY, SOME ASPECTS OF BIOLOGY AND POPULATION DYNAMICS OF THE SILVERBELLIES (PISCES : LEIOGNATHIDAE) EXPLOITED ALONG THE KERALA COAST, INDIA

**THESIS SUBMITTED**
**IN PARTIAL FULFILMENT OF THE REQUIREMENTS**
**FOR**
**THE DEGREE OF**



**DOCTOR OF PHILOSOPHY**

IN FISH AND FISHERIES SCIENCE
(MARICULTURE)

OF THE
**CENTRAL INSTITUTE OF FISHERIES EDUCATION**
**(DEEMED UNIVERSITY)**
**VERSOVA, MUMBAI 400 061**

**BY**
## K. J. ABRAHAM M. Sc.



**CENTRAL MARINE FISHERIES RESEARCH INSTITUTE**
***(Indian Council of Agricultural Research)***
**P. B. NO. 1603, COCHIN 682 014**
**INDIA**

**NOVEMBER 2001**

केंद्रीय समुद्री मात्स्यिकी अनुसंधान संस्थान
पोस्ट बॉक्स सं 1603, एरणाकुलम, कोचीन-682 014

भा कृ अनु प
ICAR

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
POST BOX No. 1603, ERNAKULAM, COCHIN- 682 014
(भारतीय कृषि अनुसंधान परिषद)
(Indian Council of Agricultural Research)

Phone (Off) : 394867/....Ext. 391407
Telegram : CADALMIN EKM
Telex : 0885-6435 MFRI IN
Fax : 0484394909
E-mail : mdcmfri@md2.vsnl.net.in



## CERTIFICATE

Certified that the thesis entitled **Studies on the Taxonomy, Some Aspects of Biology and Population Dynamics of the Silverbellies (Pisces: Leiognathidae) Exploited Along the Kerala Coast, India** is a Record of Independent *bona fide* Research Work carried out by Mr. Abraham, K.J during the period of study from November 1996 to November 2001 under our supervision and guidance for the degree of Doctor of Philosophy in Fish and Fisheries Science (Mariculture) and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or any other similar title.

**Major Advisor/ Chairman**

**(Dr. V. Sriramachandra Murty)**
Principal Scientist and Head
Division of Demersal Fisheries

**Advisory Committee**

**(Dr. M. Srinath)**
Principal Scientist and Head,
Division of Fishery Resources Assessment

**(Dr. N.N. Pillai)**
Principal Scientist (Retd.),
Division of Crustacean Fisheries

**(Dr.K.V. Somasekharan Nair)**
Principal Scientist,
Division of Demersal Fisheries

**(Dr. K. Sunil Kumar Mohamed)**
Senior Scientist,
Division of Molluscan Fisheries

# DECLARATION

I hereby declare that this thesis entitled **"STUDIES ON THE TAXONOMY, SOME ASPECTS OF BIOLOGY AND POPULATION DYNAMICS OF THE SILVERBELLIES (PISCES: LEIOGNATHIDAE) EXPLOITED ALONG THE KERALA COAST, INDIA."** is an authentic record of the work done by me and that no part there of has been presented for the award of any degree, diploma, associateship, fellowship or other similar title.

November 2001
Kochi

**(K.J. ABRAHAM)**
Ph.D. Scholar
Central Marine Fisheries
Research Institute

## ACKNOWLEDGEMENTS

*I had great privilege to work under the able guidance of Dr. V.Sriramachandra Murty, Head, Division of Demersal Fisheries, CMFRI. I take this opportunity to express my deep sense of gratitude for suggesting this problem and for giving me invaluable guidance with constant encouragement.*

*I acknowledge the present Director, CMFRI, Kochi Dr. Mohan Joseph Modayil and former Directors of CMFRI Dr. M. Devaraj, Dr. V.N. Pillai. for providing the necessary facilities at the Institute for my research work.*

*I am grateful to my advisory committee members, Dr. N. N. Pillai, Principal Scientist (Retd.), CFD , CMFRI, Dr. M. Srinath, Principal Scientist & Head of Division, FRAD, CMFRI, Dr. K. Sunil Kumar Mohamed, Scientist (Sr. Scale), MFD, CMFRI and Dr. K.V Somasekharan Nair, Senior Scientist, DFD, CMFRI, Kochi, for their sincere help offered to me during the course of my work.*

*With much gratitude I thank Dr. L. Krishnan, Principal Scientist, DFD, CMFRI, Dr. K. K. Joshi, Senior Scientist, DFD and Sri Satish Sahayak, Senior Research Fellow, DFD CMFRI, Kochi, for their incessant support and constant encouragement. I thank Mr. N. Rudhramurthy, T-3, CMFRI, Kochi, for all the help extended to me with the computer work. I thank Mr. K. Balachandran, Technical officer, CMFRI and Mrs. Rekha J.Nair for the help and advice offered to me during the course of my work. I also thank Mrs. N. Yesodha for her help in all the office work.*

*I am highly indebted to all the Staff and Scientists of the Demersal Fisheries Division, CMFRI, for their wholehearted support during the course of my work.*

*I also wish to thank Mr. Badrudeen, Technical Officer, DFD, MRC of CMFRI for helping me with the sample collection at Mandapam.*

*I owe the deepest sense of gratitude to Dr. R. Paulraj, officer–in–charge, and Dr C. Suseelan, former, OIC, PGPM, CMFRI, for providing timely help in all matters concerned with my Ph.D. programme. I also gratefully acknowledge the help extended by the PGPM staff.*

*I am thankful to the fisheries resources assessment division , CMFRI, for providing the fish landings data.*

*I am highly indebted to my brother Mr. K.J. Mathew, for all his help with the computer work.*

*I take this opportunity to acknowledge with fond remembrance, all my colleagues and friends, for their unstinted help and constant encouragement, without which the work would not have been completed.*

*Above all, I express my gratitude to all my beloved family members, for their unfailing support, for the completion of my Ph.D. programme.*

*I acknowledge the Indian Council of Agricultural Research, for the award of Senior Research Fellowship.*

# सारांश

लियोग्नाथिडे कुटुम्ब की मछलियाँ पारिस्थितिक तंत्र की प्रमुख चारा मछली होने के साथ साथ मानव उपभोग के लिए सस्ता खाद्य स्रोत भी हैं . इनकी पकड़ में भारत के समुद्रवर्ती राज्यों में केरल को द्वितीय स्थान है लेकिन केरल तट में सामान्य रूप से और पश्चिम तट में विशेष तौर पर इन मछलियों की जीवसंख्या और वर्गीकरण विज्ञान की विशेषताओं पर शास्त्रीय आंकड़ा उपलब्ध नहीं है . वर्तमान अध्ययन असल में इस कमी की पूर्ती के लिए किया गया है .

इन मछलियों के वर्गीकरण विज्ञान पर विस्तृत अध्ययन किया गया . पहले इनकी 11 जातियों पर पश्चिम तट से जानकारी प्राप्त हुई है लेकिन इस अध्ययन से 5 और जातियों पर प्रकाश डाला जा सका. 16 जातियों में हर एक मछली पर पर्याप्त विवरण संग्रहित किया गया. दो प्रमुख जातियाँ जैसे *लियोग्नाथस स्प्लेन्डेन्स* और *सेक्यूटर इन्सिडाटर* के अंडजनन, प्रथम परिपक्वता पर लंबाई और जननक्षमता पर अध्ययन किया गया. इस विषय पर एक आलोचनात्मक अध्ययन करने के उपरांत इन जातियों की परिपक्व अवस्था पर विश्वासयोग्य और वस्तुनिष्ठ मापन क्रम विकसित किया गया.

वर्ष 1998 और 1999 के दौरान विकसित डाटाबेस के आधार पर पांच जातियों (*एल.स्प्लेन्डेन्सिस, एल. ब्रेविरोस्ट्रिस, एस. इन्सिडेटर, एस. रुकोनियस* और *जी.माइनूटा*) की बढती लंबाई पर अध्ययन किया गया और वोन बेट्रानफी बढ़ती प्राचल का आकलन किया गया.

इन पांच जातियों की मृत्युता की विभिन्न दरें और जीवसंख्या गतिकी पर भी अध्ययन चलाया गया. केरल के अपतट से मुल्लनों की अधिकतम वहनीय पकड़ प्राप्त करने के लिए अनुयोज्य नीतियाँ और विकल्प क्षेत्र चुन लेने के लिए मिश्रित मात्स्यिकी निर्धारण भी चलाया गया.

दो वर्षों के दौरान मुल्लनों की पकड़ की रीति का मॉनीटरन किया गया और पूरे इस वर्ग की प्रचुरता तथा विभिन्न जातियों की प्रचुरता में अस्थायी उतार - चढ़ाव दिखाया पड़ा.

# ABSTRACT

The fishes of the family Leiognathidae constitute a cheap source of fish for human consumption besides forming a major forage item in the ecosystem. The landings of these fishes in Kerala occupy the second position among the maritime states of India but there are no scientific data on the characteristics of the populations and taxonomy of these fishes from the Kerala coast in particular and from the Indian west coast in general. The present study was taken up to fill in this lacuna.

A detailed study was carried out on the taxonomy and a total of 16 species are reported now against the 11 species known so far from west coast and adequate descriptions of each of the 16 species made. The spawning, length at first maturity and fecundity of two major species: *Leiognathus splendens* and *Secutor insidiator* are studied. A reliable and objective scale of maturation stages has been developed for these species after a critical review of the subject.

The growth in length of five species (*L. splendens, L. brevirostris, S. insidiator, S. ruconius* and *G. minuta*) has been studied on the basis of the database developed during 1998 and 1999 and Von Bertalanffy growth parameters estimated.

The different rates of mortality (total, natural and fishing) have been estimated in five species and population dynamics studied. Mixed fisheries assessment also has been carried out to arrive at the strategies and range of options for achieving maximum sustainable yield of silverbellies from off Kerala.

The landing pattern of silverbellies over the two year period has been monitored and the temporal variations in abundance of the group as whole as well as different species have been brought out.

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# Introduction

# INTRODUCTION

The burgeoning world population has prompted mankind to exploit new and varied avenues for acquiring food. The sea is often seen as a vast and endless source of food for mankind. The fishery resources of the sea have been exploited by man from time immemorial and the recent rapid strides in technology have enabled him to utilise the vast and deep expanses of the oceans effectively. The total annual world fish production is estimated as 92.86 million tonnes in 1999. Of this, production from marine fisheries alone accounted for 84.6 million tonnes (FAO, 1999). India ranks eighth (FAO, 1999) in the total fish production in the world. With its long coastline of 8129 km and an extensive Exclusive Economic Zone of 2.02 million sq km, with an estimated fishery resources potential of 3.9 million tonnes (Anon, 2000), the importance of the marine fisheries sector in the national economy, food security and employment generation need not be overemphasised. In the 3651 fishing villages situated along the coastline, about one million people are employed full time in marine capture fisheries. The fishing sector dominated by small scale and semi industrial operations, support several ancillary industries such as boat building yards, processing plants etc (Devaraj and Vivekanandan, 1999).

Marine fisheries operations have grown from a subsistence level carried out almost exclusively by the traditional fishermen in the pre-independence days, to that of a capital-intensive industry requiring close monitoring and management for their sustainability. In the course of the past over five decades of independence, the average annual marine fish production increased from six lakh tonnes in the fifties to the current level of 2.72 mt in 2000.

The mechanisation of indigenous artisanal fishing craft and the introduction of modern gear materials during the fifties, introduction of synthetic gear materials during the sixties, advent of purse seining and the motorisation of artisanal craft in the seventies and the substantial growth of motorised artisanal craft operating ring-seines in the eighties were some of the factors contributing to the phenomenal growth of the fisheries sector (Devaraj *et al.*, 1997).

The fishery resources potential in the Indian EEZ is estimated as 3.9 million tonnes. Of this demersal stocks form 2.01 million tonnes, coastal pelagic stocks 1.67 million tonnes and oceanic resources 0.24 million tonnes (Anon 2000). With the estimated per capita fish consumption of 11kg, the nation is expected to require 7.2 mt of fish by 2020 A.D (CMFRI, 1997b).

Indian seafood has been able to make a mark for itself in the international market owing to its superior quality and innovative value-added products. During the year 1999-2000, India exported 3,43,031metric tonnes of seafood valued at Rs 5116.67 crores. The share of marine products in the total export earnings of the country was 3.14% during the year 1999-2000 (MPEDA, 2000). Marine capture fisheries thus constitute a highly productive sector and is a valuable source of food and employment generation. In view of the important role played by the marine fishery resources in the socio-economic welfare of the nation, basic research on exploited fish stocks constitute a priority area in fisheries research and development.

The marine finfish resources of the country include major pelagic groups like sardines, mackerel, anchovies, Bombay duck, seer fishes, tunas, ribbon fishes and important demersal, groups such as elasmobranchs, catfishes, croakers, thread fin breams, silverbellies, lizard fishes, flatfishes, groupers, snappers and goat fishes.

Fishes of the family *Leiognathidae*, popularly called silverbellies, pony fishes, slipmouths or toothponies (Mullan in Malayalam, Karal in Tamil, Karalu in Telugu) are small to medium sized fishes living at the bottom in shallow coastal waters. They constitute an important group of demersal resources contributing to the fisheries along the Indo-West Pacific region being exploited by bottom trawls, shore-seines, gillnets, ring-seines, bagnets, etc. Some species occur in dense schools offering great potential for commercial exploitation. A few species enter brackish water. Being small, these fishes constitute forage item for many carnivorous demersal fishes. They are consumed very less in the fresh condition, but there is demand for dried or salt-cured fish and they are an important source of fishmeal also.

The total landings of silverbellies in India have been estimated at 53,498 tonnes in 1999 (CMFRI, 2000).

Considerable research work has been done on the distribution, taxonomy, biology, and fisheries of the silverbellies (Arora 1952; Balan 1963; James and Adolph 1965; James 1967, 1969,1973b,1975,1986; Mahadevan Pillai, 1972; Venkataraman and Badrudeen 1974; James and Badrudeen 1975, 1981, 1986, 1990; Rani Singh and Talwar 1978a, 1978b; Annam and Dharmaraja 1981; Kurup and Samuel 1983; Murty 1983, 1990; Jayabalan 1985, 1986, 1988; Jayabalan and Ramamoorthi 1985a, 1985b, 1985c, 1986; Pillai and Dorairaj 1985; Vivekanandan and Krishnamoorthi 1985; Reuben *et al* 1989; Srinath 1989; Hameed Batcha and Badrudeen 1992; and Jayabalan and Krishna Bhatt 1997). Population dynamics of dominant species from particular localities have also been studied (Venkataraman *et al.*, 1981; Murty 1985,1986a,b, 1990, Murty *et al.*, 1992 and Karthikeyan *et al.*, 1989). FAO Species Identification Sheets for silverbellies were prepared by James (1984). The osteology of silverbellies was studied by Rani Singh and Datta (1984) and James (1985). Rao (1967a) studied certain aspects of the physiology of these fishes.

The brief review given above reveals that almost the entire research effort on Indian silverbellies has been along the east coast of India; particularly along Andhra Pradesh and Tamilnadu coasts. While silverbellies are most dominant in this region they constitute a reasonably good fishery along the southwest coast of India also. The estimated annual average landings of silverbellies along Kerala coast during 1993 - 1997 was 4743 tonnes, which formed 7.8% of the silverbelly landings along the Indian coast during the period. However, attempts at understanding the fishery and biological characteristics of silverbellies along the Kerala coast have been quite insignificant. The only work on these fishes from Kerala coast was by Balan, (1963) on the biology and fishery of *L. bindus* and, Kurup and Samuel, (1983), on their taxonomy from Vembanad Lake. A detailed study on the, taxonomy, biology and fishery of silverbellies from off Kerala coast has been considered an important step towards understanding the characteristics of this resource in this region to fill in the lacuna in the knowledge on this resource. It is with this background that the present study has been undertaken.

The validity of any work on the biology, ecology, physiology etc, of a species depends upon the correct identification of the particular species. Without a sound taxonomic background, any further work on the species in question is rendered useless. An attempt has been made to study the taxonomy of all the species collected from commercial landings and define these adequately. The study has been made on sixteen species collected during the study period. The results are given in Chapter I.

Knowledge on maturation, spawning and fecundity are essential in assessing the recruitment of an exploited stock. The results of the study on these aspects are incorporated in Chapter II.

A sound knowledge of the growth of exploited fish stocks is essential to understand their population dynamics. A detailed investigation has been carried out on five dominant species and the results are present in Chapter III.

A major task of the fishery scientist is to estimate the stock size of exploited fish population, formulate strategies for rational exploitation and render advice to the Governments accordingly. The results of a detailed study on single species assessments and mixed fisheries assessment of five important species are incorporated in Chapter IV.

A study has been taken up with a view to understanding the pattern of landings, species composition and their temporal variations in abundance in the trawling grounds off Kerala as reflected in the landings. The details of this study are incorporated in Chapter V.

# Database

# DATABASE

The study was conducted on the basis of data collected over a period of twenty four months from January 1998 to December 1999 from Cochin Fisheries Harbour and Neendakara Fisheries Harbour, which are the major trawl landing centres in Kerala (Fig. 1). The Cochin Fisheries Harbour is the major landing centre for trawlers in Ernakulam district; the other centres being Munambam, Kalamukku and Murikkumpadam. Neendakara fisheries harbour located in Quilon district, along with the Sakthikulangara fisheries harbour constitute the major trawl landing centres in Quilon district with minor trawl landings at Thankassery and Vadi. The landings begin in early morning and continue late in the night. Both these landing centres provide a landing ground for a variety of craft-gear combinations like trawlers of multiday and single day operations, mechanised purse-seines, mechanised drift gillnets, mechanised hook and lines, outboard hook and lines, outboard ring-seines etc. Since the trawl nets contribute more than ninety percent of the landings of silverbellies at both these centres, sampling was done only from these units. Sampling was done at weekly intervals from Cochin fisheries harbour and at fortnightly intervals from Neendakara. On each sampling day the units to be sampled were selected following Alagaraja (1984). From each of the vessels sampled, information was collected on

a) The area of the trawling operation - by enquiry

b) The depth of trawling - by enquiry

c) Mesh size of the cod end of the trawl net . - by direct observation

d) The total silverbelly catch . - by observation

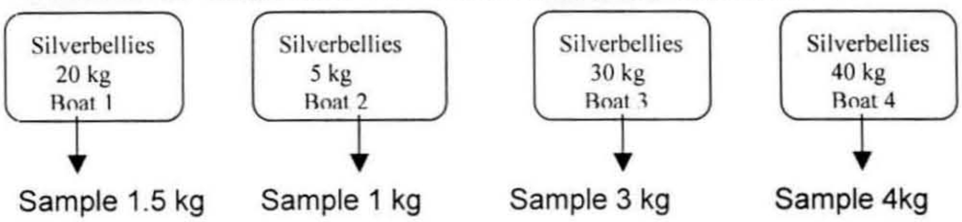
The sampling programme was implemented over the entire period of landings on the day.

The sampling strategy for species composition and biology was designed to take into account the differences arising out of sorting the catch onboard, depth and area of fishing. On each observation day, samples were collected from at least 6 units. From each unit a random sample was collected and placed in a bag, the total catch of silverbellies in the boat was noted on a slip of paper and placed in the bag. The samples collected in such bags were packed in ice in insulated containers, brought to the laboratory and kept in freezer. For purpose of making estimates at the level of Kerala state, the monthly data on gear-wise and district-wise landings of silverbellies during 1998 and 1999 were taken from the Fisheries Resources Assessment Division of the Central Marine Fisheries Research Institute.

## ANALYSIS OF FISH SAMPLES

In the laboratory, the samples were thawed and sorted by species. The weight of each species in each bag was taken and raised to the estimated catch of silverbellies in the boat sampled. Similarly data on length was taken on each species in each bag and weighted to the total catch of the species in the boat. The estimated weights of each species in the different boats sampled were pooled and raised to the total catch of silverbellies of the day. Similarly, the estimated length composition of the catch of each species from different boats were also pooled and weighted to the total estimated catch of the species of the day. The estimates thus obtained on observation days were pooled and then raised to the estimated catch of the month as per Alagaraja (1984).

**SCHEME OF SAMPLING OF SILVERBELLIES ILLUSTRATED**




The above figure illustrates the scheme of sampling followed. For studies on species composition and length composition, each species in each sample were first weighted to the total catch of silverbellies in the boat. Thus

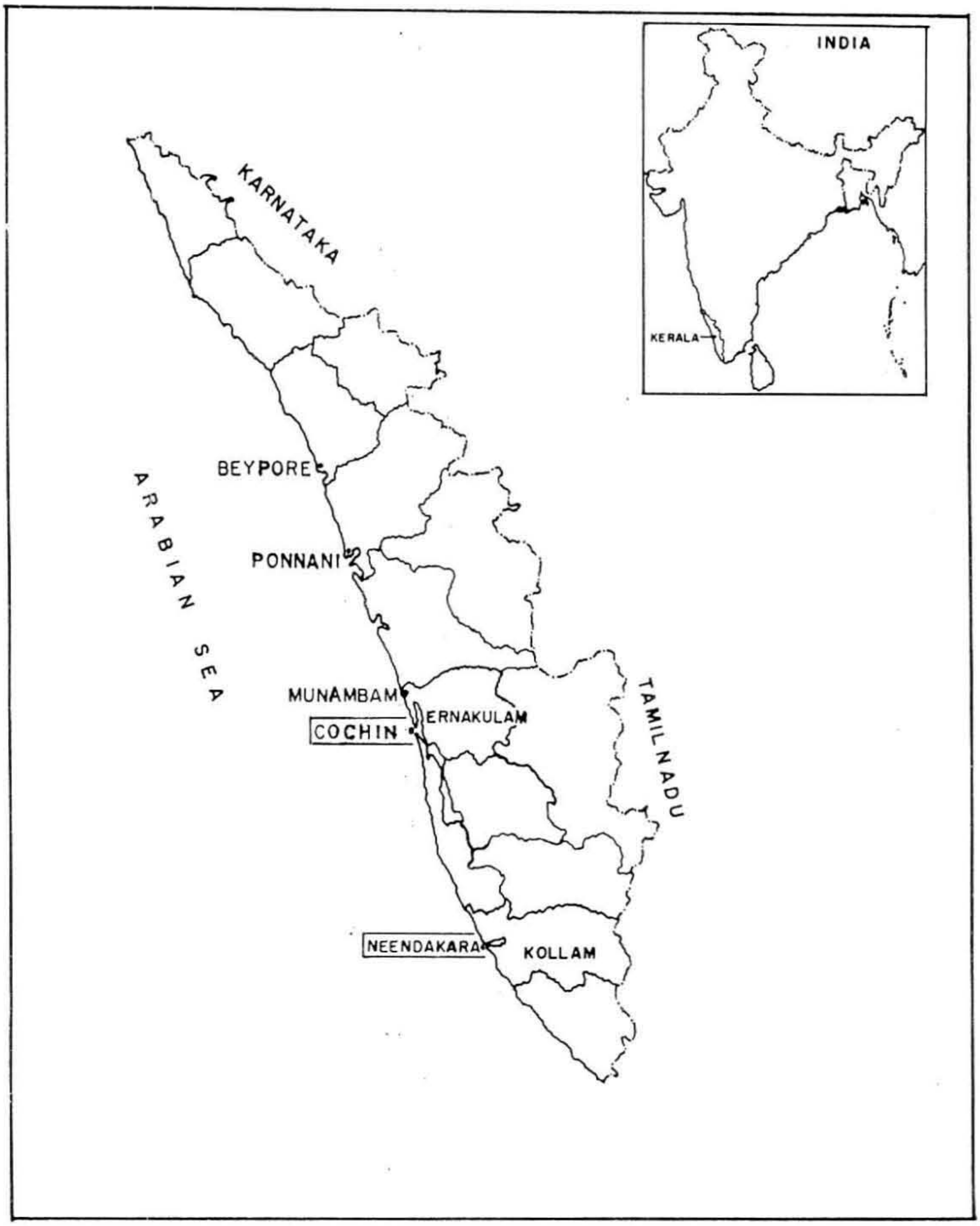



Figure 1 Map of Kerala showing different trawl landing centres. Sampling centres are shown in rectangles

from the above example, from the 1.5 kg of silverbellies collected from Boat I containing 20 kg of silverbellies, the weight of each species in the sample is first raised to the 20 kg. After each sample was thus raised to the catch of the boat, data of the 4 boats pooled (i.e. 20+5+30+40= 95 kg) and the species composition and length composition in each boat were also pooled up to get the estimate in the 4 boats (95 kg) sampled. The different estimates of the boats were then raised to the estimated catch of the day. The estimates of all the observation days were then pooled and weighed to the estimated catch of the month.

Detailed biological data were collected on two species- *Leiognathus splendens* and *Secutor insidiator,* since they are the two most abundant species landed in the group. Length data were collected in five species *L. splendens, L. brevirostris, S. insidiator, S. ruconius* and *Gazza minuta.*

The weight of each individual fish was taken in a Sartorius Monopan Balance after removing the moisture with a blotting paper. The specimens were then cut open and sex and stage of maturation noted. In females, the ovary was carefully taken out without damage, external moisture was blotted out carefully and its weight taken in a Sartorius Balance and then preserved.

For taxonomic study, specimens of all species occurring in the commercial landings covering the entire length range were collected and preserved in 5% formalin after injecting 5% formalin through the vent and dorsal musculature. The specimens were preserved in a wide mouthed bottle in such a manner that the shape is not distorted during storage. Morphometric and meristic data were taken following Hubbs and Lagler (1947). Morphometric measurements were taken using a measuring board and meristic counts taken using a binocular stereozoom microscope.

# Chapter I

# Taxonomy

# TAXONOMY

## INTRODUCTION

Fishery resources constitute one of the most important renewable resources. With increasing fishing pressure, the only option left for the sustainability of the fisheries, is their rational management. Proper management is possible with a thorough knowledge of the dynamics of the fish stocks. For a meaningful study of the dynamics, knowledge of natural history of the species is necessary and this in turn can be acquired by the correct identification of fish species. This assumes greater importance in tropical seas where, a multitude of closely resembling species occur. As even the closely resembling species may vary widely in biological characteristics, the role of taxonomy cannot be overstressed in studies on population dynamics. The study is also a step towards understanding the bewildering biodiversity that characterises the tropical seas.

Pioneering studies on taxonomy of Indian fishes began in the late 18$^{th}$ century by European scientists and officers of the British East India Company. One of the pioneers was Bloch (1795), and his student Schneider (1801), followed by Lacepede (1798-1803). In 1794, Dr. Buchanan Hamilton, Superintendent of the Botanical gardens, Calcutta, took up a study of the fishes of the Ganges, and completed after 28 years (Hamilton , 1822) which was probably the first official catalogue of Indian fishes. Hamilton was followed by Cuvier and Valenciennes (1828-1849) and Gunther (1860). Dr. Alcock who undertook the first marine fisheries survey in India published the findings in 1869. Perhaps the most important work during this period, pertaining to the subject was that of Sir Francis Day, Surgeon Major with the British troops in Bengal, who studied the systematics of Indian fishes in depth for over 20 years. His monumental work was published in two volumes as the 'The Fishes of India: being a natural history of the fishes known to inhabit the seas and freshwaters of India. Vol. I and II' (1878) and the 'The Fauna of British India, including Ceylon and Burma' (1889).

During the subsequent period of one century, a large number of fishes have been described and added to the list already prepared by Day, and the important works during this period with regard to the taxonomy of fishes of the Indian waters are by Munro (1955), Jones and Kumaran (1980), who published descriptions of over 600 species from Laccadives archipelago, Talwar and Kacker (1984), and the most recent compilation is that of Talwar and Jhingran (1991a , 1991b), who published descriptions of a total of 930 species of inland (fresh and brackish water ) fishes of India.

## REVIEW OF LITERATURE

In regard to the taxonomy of the family Leiognathidae from the Indian waters , Day (1878), described 14 species. Munro (1955), described twelve species of silverbellies from the neighbouring Sri Lanka. James (1967, 1969), Rani Singh and Talwar (1978a, 1978b), Jayabalan (1985) and James and Badrudeen (1990), together added seven species to the known silverbelly species of India of which four were new to science and three, the first reports from India. The most thorough and only comprehensive revision of the family Leiognathidae from the Indian seas was that of James (1975). Jayabalan and Ramamoorthi (1977) gave a synoptic key to the genera of Leiognathidae of Porto Novo. Talwar and Kacker (1984) described 15 species. James (1984) described 17 species of silverbellies from the Western Indian Ocean.

The taxonomy of Leiognathids was dealt with by many workers around the world. Everman and Seale (1907) described 9 species of silverbellies from the Philippine islands, under the family Equulidae, of which two were new species. Weber and De Beaufort (1931) gave the descriptions of 16 species from the Indo-Australian archipelago. Fowler (1949), described 5 species of leiognathids from Oceania. Umali (1950) gave a key to the family leiognathidae (8 species) from Philippines. Mendis (1954) gave a key to 8 species of leiognathids from Ceylon. Smith (1961) described 4 species from South Africa. Marshall (1964) gave a key to the Leiognathid genera of Australia. Tiews and Caces Borja (1965) gave an identification key to 17 species from the San Miguel Bay, Philippines. Munro (1967) described 9 species from New Guinea. Kuhlmorgen-Hille (1968), gave a field key to the fishes of the family Leiognathidae from the Gulf of Thailand. Lindberg and Krasyukova (1969) described 6 species from Japan and gave a key to the species from Japanese waters. Kuhlmorgen-Hille (1974) listed 31 species and gave the descriptions of 13 species of silverbellies from the eastern Indian Ocean. Hutomo (1975) described 11 species from Indonesia. Rau and Rau (1980) described 14 species from Philippines. Schroeder (1980) described 8 species from Philippines. Masuda *et al.*, (1984) described 10 species from Japan. Bianchi (1985 a, b) gave a field guide to 11 species of leiognathids of Pakistan and 8 species from Tanzania. Shen and Lin (1985) revised the taxonomy of leiognathid fishes, of Taiwan and its adjacent islands and they recognised 12 species belonging to 3 genera. Jones (1985), revised the Australian species of the family Leiognathidae and described 14 species. A total of 21 species of Leiognathidae known from the seas around India are listed below; the species collected in this work are shown by one and two asterisks, those marked with ** are the first reports from Kerala coast.

1. *Leiognathus splendens** (Cuvier, 1829)
2. *Leiognathus brevirostris** (Valenciennes, 1835)
3. *Leiognathus bindus** (Valenciennes, 1835)
4. *Leiognathus equulus** (Forsskal, 1775)
5. *Leiognathus dussumieri** (Valenciennes, 1835)
6. *Leiognathus blochi** **(Valenciennes, 1835)
7. *Leiognathus daura** (Cuvier, 1829)
8. *Leiognathus elongatus*** Gunther, 1874
9. *Leiognathus lineolatus** (Valenciennes, 1835)
10. *Leiognathus leuciscus*** (Gunther, 1860)
11. *Leiognathus fasciatus** (Lacepede, 1803)
12. *Leiognathus smithursti*** (Ramsay and Ogilby, 1886)
13. *Leiognathus berbis* (Valenciennes, 1835)

14. *Leiognathus jonesi* James, 1969

15. *Leiognathus striatus* James and Badrudeen, 1990

16. *Leioganthus indicus* Rani Singh and Talwar, 1978

17. *Secutor insidiator** (Bloch, 1787)

18. *Secutor ruconius** (Hamilton-Buchanan, 1822)

19. *Gazza minuta** (Bloch, 1797)

20. *Gazza achlamys*** Jordan and Starks, 1917

21. *Gazza shettyi* Jayabalan , 1985

The survey of literature on taxonomy of silverbellies from India clearly reveals that most of the work was carried out from the east coast, that too from the Southeast coast. The work along the west coast is restricted to that of Kurup and Samuel (1983). This is also limited to the species occurring in the backwaters of Kerala. Thus adequate biometric data are not available from the sea off the west coast of India. The literature on species distribution in different regions in India suggests wide variations in the distribution and abundance of species. Off the southern Tamilnadu coast, 19 species are known of which only about four species (*Leiognathus jonesi*, *L. dussumieri*, *L. brevirostris* and *G. minuta*) are abundant (Murty *et al.*, 1992, CMFRI 1996, 1997a, 1998, 1999, 2000), whereas along the rest of the east coast only about 11 species are reported of which only three species (*Leiognathus splendens*, *L. bindus* and *Secutor insidiator*) are abundant (Murty, 1983, 1986a, 1986b, 1990; Murty *et al.*, 1988, 1992). In the backwaters of Kerala, Shetty (1963) reported 6 species and Kurup and Samuel (1983) reported nine species which make the total known species off Kerala to be 11, only two species *L. equulus* and *L. brevirostris* were reported to be abundant. This situation suggests that the distribution of species along the west coast needs to be understood, besides developing a database on the biometry of the component species to fill the gap in the knowledge on stock identification in the different regions and the possible existence of different unit stocks. It is under this background that it was felt necessary to study the taxonomy of the species found in the sea off Kerala. While the objective was not to carry out an in depth taxonomic study, the present work attempts to define the species on the basis of morphological and biometric characteristics. A total of 16 species were collected during the present study from Kerala coast (against the 11 species known so far *vide supra*), which are described below. Thus five species are reported for the first time from the Sea of Kerala, which are also the first reports for the entire west coast.

## MATERIALS AND METHODS

Specimens for the study were collected from the fish landing centres at Cochin and Neendakara, at regular intervals, during the period from 1998-1999. After noting the fresh colour and pigmentation of the specimens they were injected with 5 % formalin. The specimens were then stored in 5 % formalin. After taking biometric data, the belly was cut open to note the sex. In most species, 30 specimens were examined for describing the species. However in certain species, which are rare in the catches, the descriptions were, perforce, based on smaller numbers only. In taking meristic and morphometric data, the methodology of Hubbs and Lagler (1947) was followed. All the linear measurements were made in the median longitudinal axis. The various morphometric measurements taken are shown (Fig. 2).

Counts of pectoral rays, pelvic rays and lateral line scales were made on the left side of the specimen only. Height of dorsal and anal fins, eye diameter, snout length, head height and height of body were taken using vernier calipers. Counts of lateral line scales and fin rays were made under a binocular stereozoom microscope.

The nomenclature of Hubbs and Lagler (1947) was followed for various meristic characters except for pectoral and pelvic fins, which are cited as P and V respectively. The dorsal fin is represented by D, Caudal by C, and anal by A. The fin spines are shown in upper case Roman numerals. In pectoral the unbranched rays are indicated by lower case Roman numerals and branched rays by Arabic numerals (e.g.: P. iii, 16, ii ; meaning , the presence of 3 unbranched rays above followed by 16 branched rays and two unbranched rays below , in the pectoral fin.). The count of caudal fin rays is that of all the branched rays plus two unbranched rays , one above and the other below. Lateral line scale count represents the number of pored scales in the lateral line.



Under each description, the number of specimens examined is indicated along with the length range and the number of males and females included, the others being fishes whose sex could not be determined.

The relationship between certain body lengths and standard length and between certain dimensions in the head and head length were calculated after ascertaining the type of relationship through a scatter diagram, following the least squares method (Snedecor and Cochran, 1967). The results are presented in the figures and the calculated values of slope and elevation, along with the value of the coefficient of determination ($R^2$) are also shown in the figures for each species. Certain body proportions for each species, are expressed as percentage of standard length and certain proportions in the head expressed as percentage of head length are given in the descriptions; the means are given in parentheses following the range for each proportion (the expressions used are predorsal for predorsal length, preanal for preanal length, dorsal base for length of the base of dorsal fin, Anal base for length of the base of the anal fin, head for head length, dorsal height for height of the dorsal fin , anal height for height of the anal fin, pectoral for length of the pectoral fin, depth for depth of the body, Snout for preorbital length or snout length and eye for horizontal eye diameter), and were found to be useful in comparing and differentiating between closely resembling species of a genus (e.g. Murty 1978) and comparison of the stocks of the same species from different localities. (Lachner and Jenkins, 1971). Since the body proportions are known to vary with growth i.e., the rate of growth of a body part changes with increase in length, a study like this assumes greater importance. Understanding such variations in growth (allometric growth) will help in understanding the intraspecific variations in each species. The frequency distribution of the various meristic characters for each species, is given along with the calculated standard deviation and standard error in the Tables.

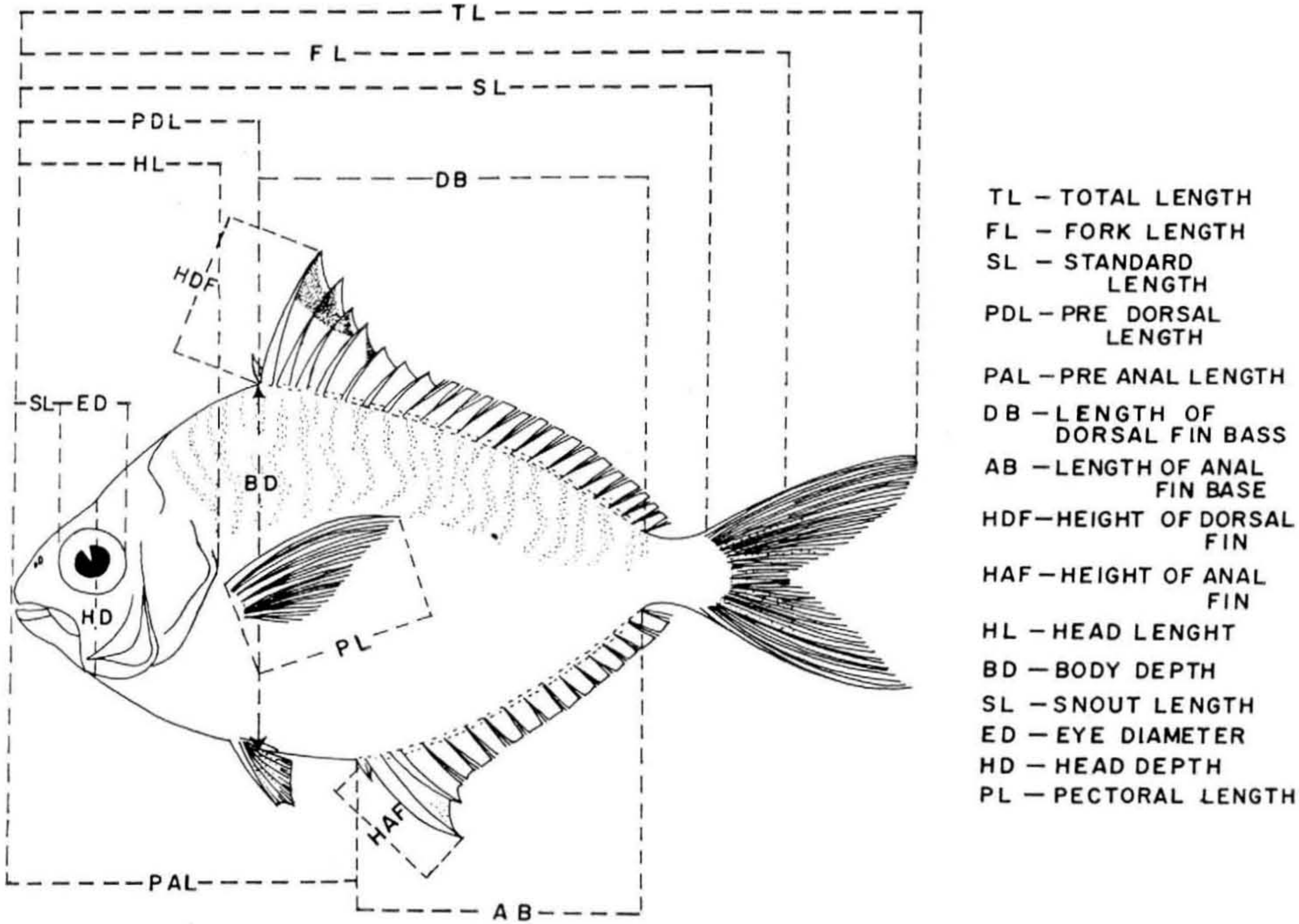



Figure 2 Definition of different morphometric data taken

In *L.bindus, L. blochi, L. lineolatus, L. elongatus, S. insidiator, S. ruconius* and *G. achlamys*, the lateral line is incomplete, either not extending to the base of the caudal fin or ending before the dorsal with the lateral line tubes becoming obsolete, which was observed by many other workers also: Day, (1878), Weber and De Beaufort , (1931), (Munro, (1955) and Shen & Lin, (1985). The lateral line counts were hence not taken in these species.

Colour descriptions of species are based on specimens in the fresh condition. For the identification of each species, standard descriptions given by various authors were consulted. The classification followed by Nelson (1976) was adopted.

Under the descriptions of each species the recorded distribution of the species in Indian waters is given. Only the original reference is cited and synonyms not given. The distribution as known in India only is given.

# DESCRIPTION OF SPECIES

## GENUS 1 *LEIOGNATHUS* LACEPEDE, 1803

(Type species: *Leiognathus argenteus* Lacepede, 1803 )

(= *Scomber equula* Forskal, 1775)

### 1. *Leiognathus splendens* (Cuvier, 1829)

(Plate I, Fig. 1; Figures 3-4; Tables 1-3)

*Equula splendens* Cuvier, 1829, *Regne Anim, dit.*, 2a, **2**: 212

*Material examined* : 30 specimens (10 females, 14 males, 6 indeterminates) ranging from 41 mm to 108 mm total length from Cochin and Neendakara, Kerala.

DESCRIPTION

D.VIII – IX, 16; P. ii, 13-14, i – ii ; V. I, 5; A. III, 14-15; C. 15-16; Ll. 45-57.

*As percent of standard length:* Total length 135.06-142.86 (138.64); fork length 116.07-123.33 (118.85); predorsal 33.33-40.51 (36.35); preanal 44.44-54.55 (51.25); dorsal base 51.85-70.51 (58.63); anal base 40.00-48.15 (43.56); head 31.34-34.62 (33.21); dorsal height 18.18-24.64 (22.14); anal height 15.69-21.28 (18.74); pectoral 20.90-27.27 (23.66); depth 40.85-55.36 (52.29) .

*As percent of head length:* Snout 22.22-31.58 (26.26); eye 33.33-44.44 (39.11); head height 77.78-95.24 (87.79).

Body compressed and deep. Anterior part of dorsal profile more strongly convex than anterior part of ventral profile. Dorsal profile with a notch above eye. Snout blunt and shorter than eye diameter. Gape of mouth below lower border of eye. Mandibles slightly concave. Minute villiform teeth in each jaw. Lower margin of pre-operculum finely serrated. Lateral line prominent and convex from the beginning, but less convex than the dorsal profile. It extends beyond the end of soft dorsal and anal fins, but stops just short of the base of caudal fin. Ventral fin with an axially scale and reaches very near the origin of the anal fin.

COLOUR: Body silvery, abdomen more silvery than back. Back greyish silvery with faint grey wavy vertical lines descending from the dorsum to a little below lateral line. Tip of snout dotted black. Pectoral axil black. Membrane between the second and sixth dorsal spines jet black and the membrane between the following spines, soft dorsal, anal spines, soft anal fin, and the caudal lobes, faint yellow. Tip of caudal lobes dusky.

DISTRIBUTION: Most widely distributed along the Indian coast, contributing to the fishery, along with other species, especially along the west coast of India. It is known from Veraval, Mangalore, Calicut, Cochin, Mandapam, Porto Novo, Madras, Visakhapatnam and Kakinada.

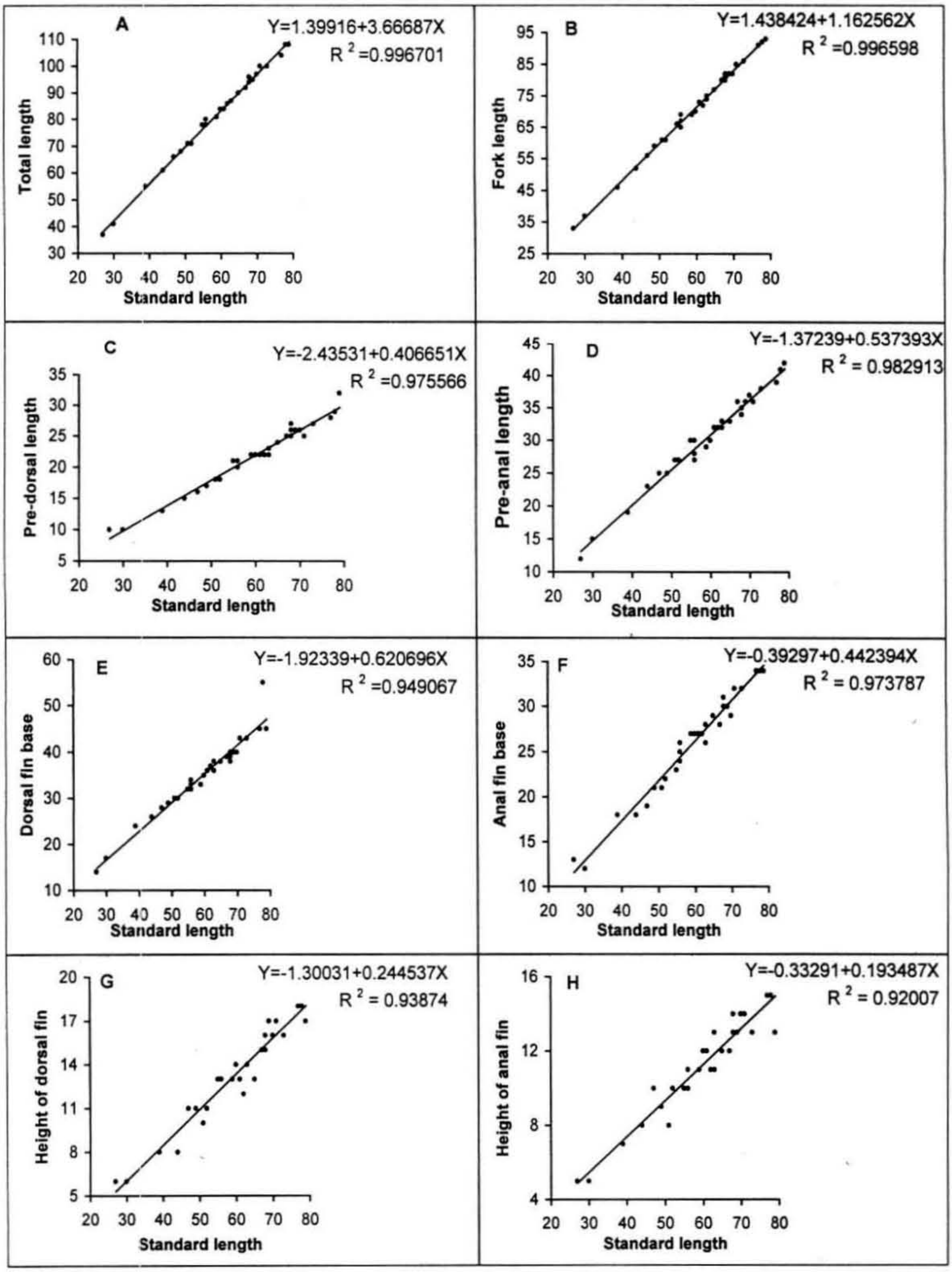



Figure 3

*L.splendens:*

Regression of
A) Total length on Standard length
B) Fork length on Standard length.
C) Predorsal length on Standard length
D) Preanal length on Standard length.
E) Dorsal fin base on Standard length
F) Anal fin base on Standard length.
G) Height of dorsal fin on Standard length
H) Height of anal fin on Standard length.

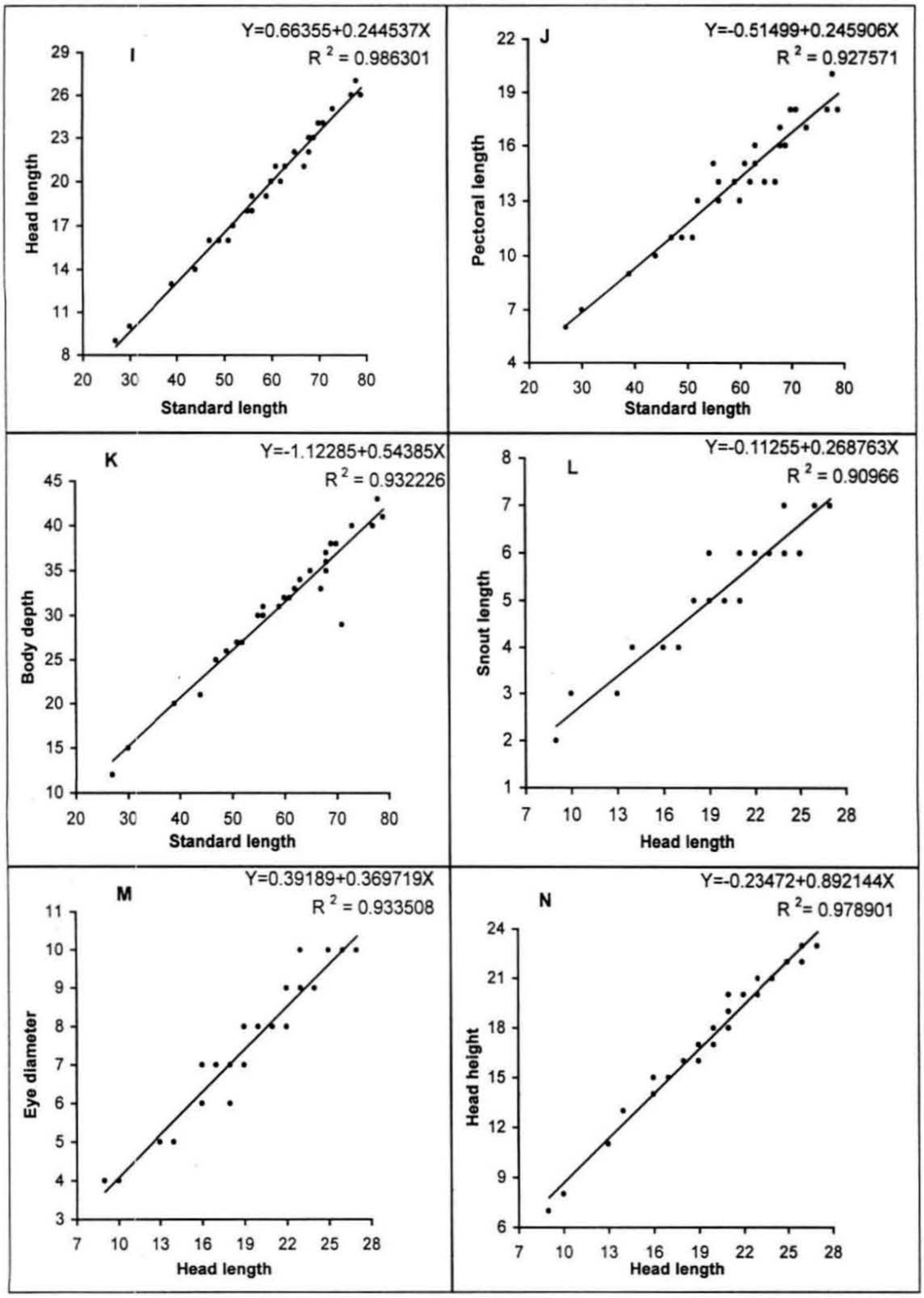



Figure 4

*L.splendens:*

Regression of I) Head length on Standard length J) Pectoral length on Standard length.
K) Body depth on Standard length L) Snout length on Head length.
M) Eye diameter on Head length N) Head height on Head length.

## 2. *Leiognathus brevirostris* (Valenciennes, 1835)

(Plate I, Fig. 2; Figures 5-6; Table 1-3)

*Equula brevirostris* Valenciennes in Cuvier and Valenciennes, 1835,
*Hist. Nat. poiss.*, 10 :83.

*Material examined* 30 specimens (14 females, 13 males, 3 indeterminates) ranging from 82mm to 114mm total length from Cochin and Neendakara.

DESCRIPTION

D.VIII, 16-17; P. ii, 13-15, i – iii; V. I, 5; A. III, 14; C. 15; Ll. 52-64.

*As percent of standard length:* Total length 131.82-137.31 (134.97); fork length 114.06-118.46 (115.81) ; predorsal 35.53-40.48 (37.66) ; preanal 47.69-52.38 (49.95) ; dorsal base 40.63-57.97 (55.47) ; anal base 38.81-45.21 (43.42) ; head 29.85-33.33 (31.37) ; dorsal height 15.56-26.56 (22.70) ; anal height 15.56-20.00 (18.07) ; pectoral 16.42-20.90 (18.87) ; depth 43.75-50.00 (46.19) .

*As percent of head length:* Snout 26.32-35.71 (30.46) ; eye 30.00-36.84 (32.73) ; head height 81.82-91.30 (86.22).

Body oval and compressed. Dorsal and abdominal profiles equally convex. Mouth when protracted forms a tube directed downward. Gape of mouth immediately below or opposite to the lower margin of the eye. The lower margin of the lower jaw very concave. Teeth small and numerous in a single row in each jaw. Two small spines on top of the head opposite the front border of eye. The lower margin of the pre-operclulum finely serrated. First part of the lateral line concave later runs less convex to the dorsal profile extending posteriorly up to the base of the caudal fin. Ventrals with axillary scales and reaches two thirds of the way to the anal fin. Caudal fin deeply forked.

COLOUR: Belly silvery, Back with dark wavy vertical lines extending down to about or a little below the lateral line, anteriorly to below the origin of dorsal fin and posteriorly to the end of the soft dorsal. A brown blotch on the nape, which becomes diffuse on preservation in formalin. A conspicuous golden yellow patch on belly, about midway between the pelvis and the anal fin origin. Tip of snout, dotted black. The pectoral axil dotted black. Spinous part of the dorsal fin golden at mid height.

DISTRIBUTION: Occurs along Mangalore, Cochin, Palk Bay, Gulf of Mannar (Mandapam), Kakinada and Godavari estuary. It has also been reported from Vembanad Lake off Cochin. It is abundant in the Rameswaram region.

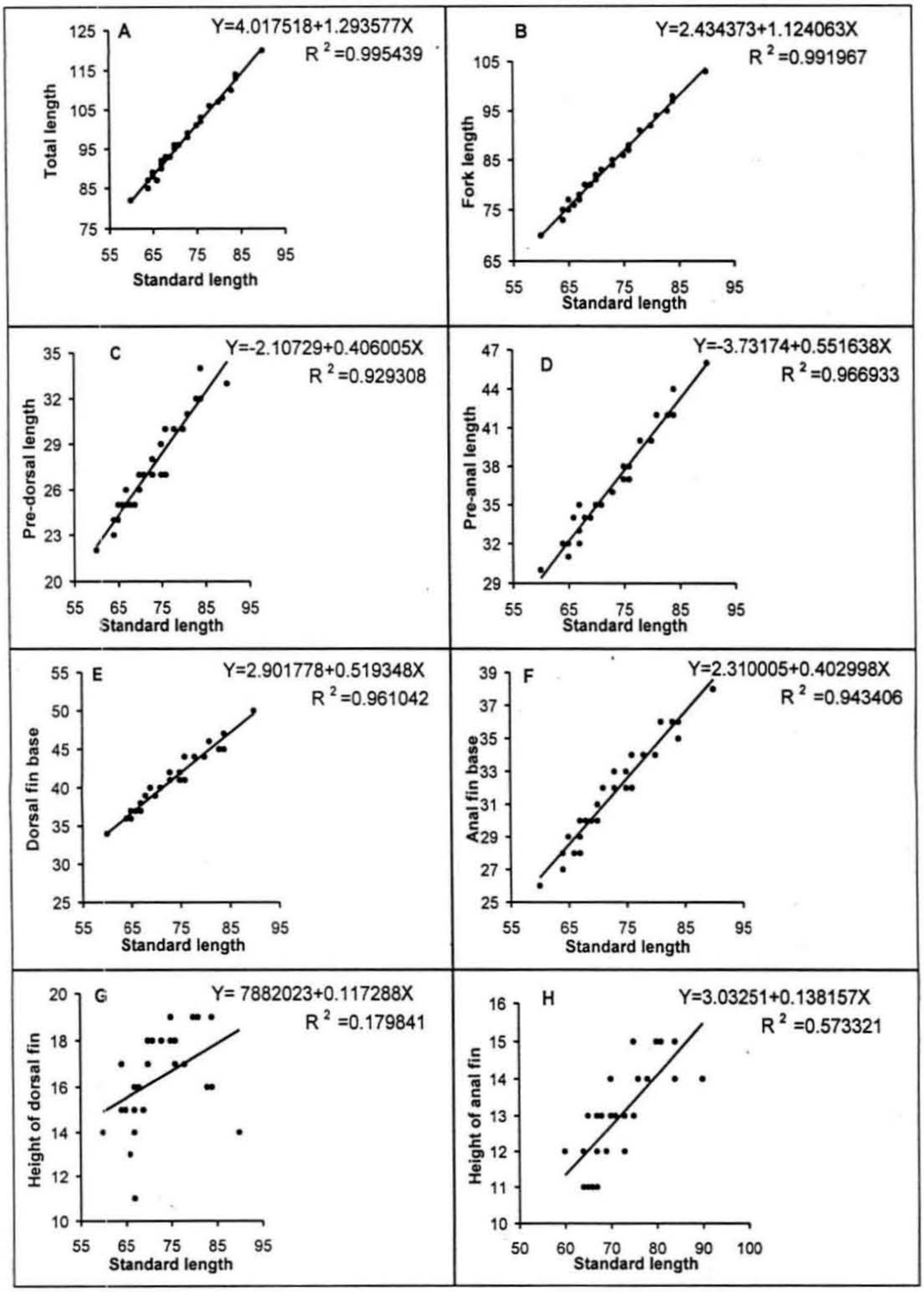



Figure 5

*L.brevirostris:*

Regression of A) Total length on Standard length B) Fork length on Standard length.
C) Predorsal length on Standard length D) Preanal length on Standard length.
E) Dorsal fin base on Standard length F) Anal fin base on Standard length.
G) Height of dorsal fin on Standard length H) Height of anal fin on Standard length.

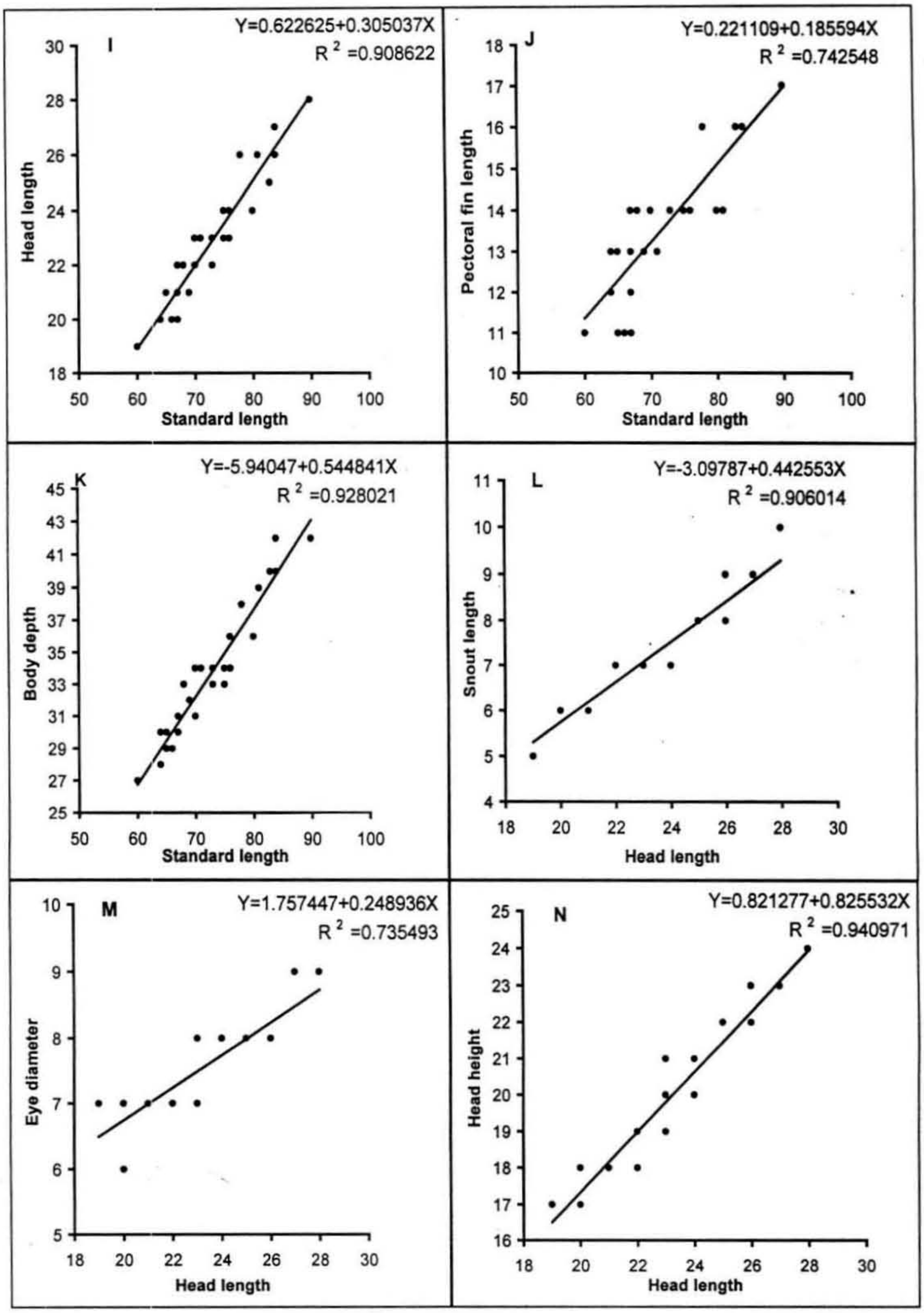



Figure 6

*L.brevirostris:*

Regression of I) Head length on Standard length J) Pectoral length on Standard length.
K) Body depth on Standard length L) Snout length on Head length.
M) Eye diameter on Head length N) Head height on Head length.

### *3. Leiognathus bindus* (Valenciennes, 1835)

(Plate I, Fig. 3; Figures 7-8; Tables 1-2)

*Equula bindus* Valenciennes 1835, in Cuvier & Valenciennes, *Hist. Nat. Poiss.*, 10 : 78.

*Material examined:* 30 specimens (6 females, 9 males, 15 indeterminates) ranging from 50 mm to 106 mm total length from Cochin and Neendakara.

DESCRIPTION

D.VIII, 16; P. ii, 11-13, ii – iii; V. I, 5; A. III, 14; C. 14-15.

*As percent of standard length:* Total length 128.95-139.66 (135.80); fork length 112.33-117.24 (114.72); predorsal 31.25-37.25 (34.61); preanal 42.31-48.65 (46.45); dorsal base 56.86-61.70 (59.35); anal base 44.74-50.91 (47.28); head 26.92-30.99 (29.11); dorsal height 15.69-21.43 (18.53); anal height 12.50-17.91 (15.17); pectoral 17.65-22.97 (20.89); depth 48.65-57.14 (54.24).

*As percent of head length:* Snout 18.18-26.67 (23.28); eye 35.00-45.00 (39.94); head height 90.91-110.53 (102.58).

Body deep oval and strongly compressed, particularly in the lower part. Ventral profile of the body more markedly convex than the dorsal profile. Abdomen before anal more strongly convex. Occipital profile shows a slight concavity and gradually rises to the dorsal profile. Protracted mouth parts point forward to slightly downward. Commencement of the gape of mouth somewhat above level of lower border of eye. Mandible slightly concave. Teeth small, numerous, in both the jaws. Two small spines on top of the head, opposite the front border of the eye. Pre-opercle with its lower margin finely serrate. First part of the lateral line straight, later running less convex to the dorsal profile and ending below the middle of the soft dorsal, posteriorly lateral line becoming obsolete. Ventrals short, their tips scarcely reaching half way to the anals. Ventral fin with a long axillary scale. Caudal fin deeply forked with spreading pointed lobes.

COLOUR: Body silvery, abdomen more silvery than back. Dark irregular, somewhat vermiculate or semicircular markings in a zigzag pattern, commencing immediately behind head and extending to the end of the soft dorsal, laterally extending down to less than half height. Spinous part of dorsal fin, black at half height, above which the membrane between the second and fifth spines bears a bright orange blotch which turns yellow on preservation in formalin. Tip of snout and ventral half of body with grey dots. Pectoral axil dotted black. Faint yellow colour on basal part of spinous anal fin membrane. Caudal especially its posterior margins are dusky.

DISTRIBUTION: Widely distributed along both the coasts, along Veraval, Mangalore, Calicut, Cochin, Palk bay, Gulf of Mannar, Madras, Kakinada, Visakhapatnam and West Bengal. It forms a significant part of silverbelly fishery in Gujarat, Tamilnadu.

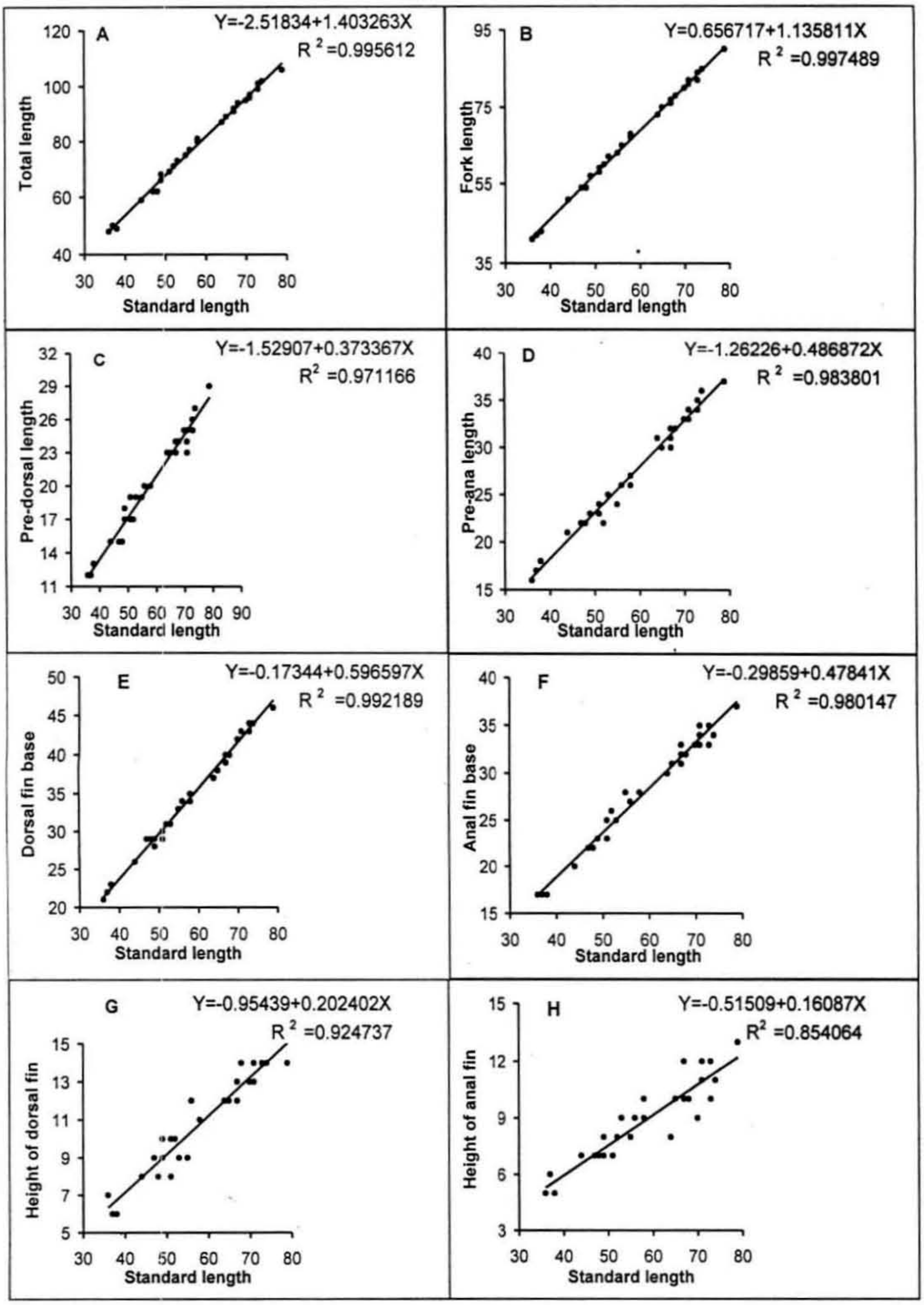



Figure 7

*L.bindus:*

Regression of A) Total length on Standard length B) Fork length on Standard length.
C) Predorsal length on Standard length D) Preanal length on Standard length.
E) Dorsal fin base on Standard length F) Anal fin base on Standard length.
G) Height of dorsal fin on Standard length H) Height of anal fin on Standard length.

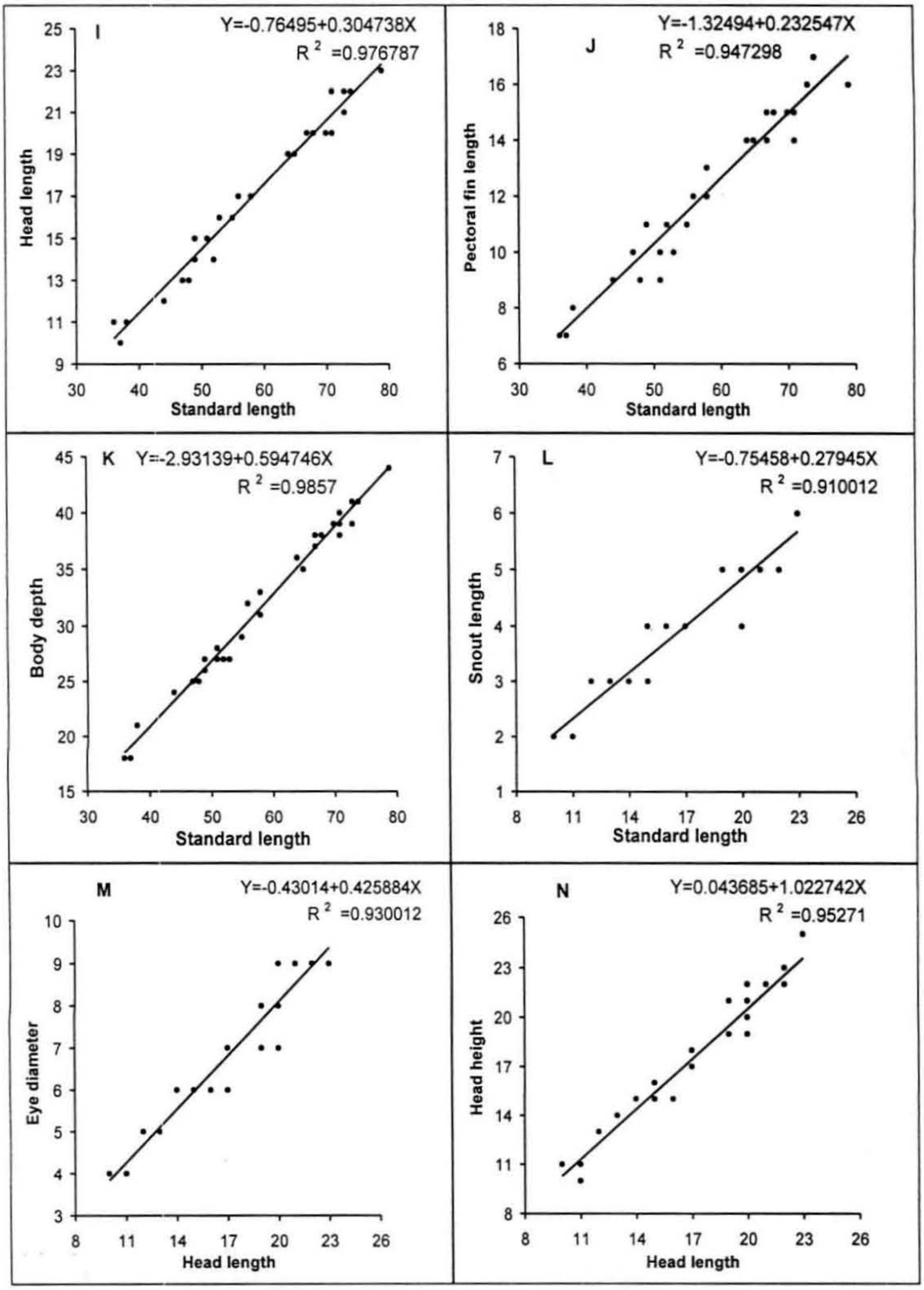



Figure 8

*L.bindus:*

Regression of I) Head length on Standard length J) Pectoral length on Standard length.
K) Body depth on Standard length L) Snout length on Head length.
M) Eye diameter on Head length N) Head height on Head length.

### 4. *Leiognathus equulus* (Forskal, 1775)

(Plate I, Fig. 4; Figures 9-10; Tables 1-3)

*Scomber equula* Forskal, 1775, Descr. *Animal*, p.75

*Material examined* : 30 specimens (6 females, 23 males, 1 indeterminate) ranging from 79 mm to 126 mm total length, from Cochin and Neendakara.

DESCRIPTION

D.VIII, 16-17; P. ii, 15-17 , i – iii ; V. I , 5 ; A. III , 13-14 ; C. 15 ; Ll. 54-64.

*As percent of standard length:* Total length 134.88-142.68 (137.73); fork length 115.12-120.73 (117.40); predorsal 37.21-43.75 (40.17); preanal 48.84-54.88 (51.45); dorsal base 50.72-56.18 (53.54); anal base 40.00-45.00 (42.58); head 31.40-35.94 (33.50); dorsal height 22.09-27.78 (24.70); anal height 18.99-22.22 (20.48); pectoral 20.00-26.09 (23.22); depth 53.45-60.00 (56.80).

*As percent of head length:* Snout 28.57-35.71 (32.18); eye 31.25-37.93 (35.20); head height 88.89-104.35 (95.21).

Body oblong, deep and compressed. Dorsal profile more convex than the ventral profile; gently elevated from the occipital region to form a strongly humped back. Snout blunt. Mouth with thick lips. Mouth pointing downwards when protracted. Commencement of gape of mouth below lower border of eye. Lower margin of lower jaw strongly concave. Teeth small, numerous, villiform, in each jaw. Two small spines on top of the head, opposite front border of the eye. Pre-opercle with its lower margin slightly concave and serrated. Lateral line, conspicuous, concave at first, later on becomes convex, but less convex than the dorsal profile, and extends almost up to the base of the caudal fin. Ventrals do not reach the origin of the anal fin and has a prominent axillary scale, and a strong spine. Caudal fin not deeply forked and with rounded lobes.

COLOUR: Body silvery, back greyish. Close set fine vertical bands descend from back to about mid height, clearly seen in fresh specimens, but fade on preservation in formalin. Membrane between anal spines yellowish. Snout dotted black. Pectoral fin axil faintly dusky. Posterior margin of caudal lobes pale yellow and dusky.

DISTRIBUTION: Along Bombay, Mangalore, Calicut, Cochin, Quilon, Cape Comorin, Mandapam, Rameswaram, Kilakarai, Pamban, Madras, Porto Novo, Visakhapatnam, Kakinada. Also found in Godavary estuary and Chilka Lake.

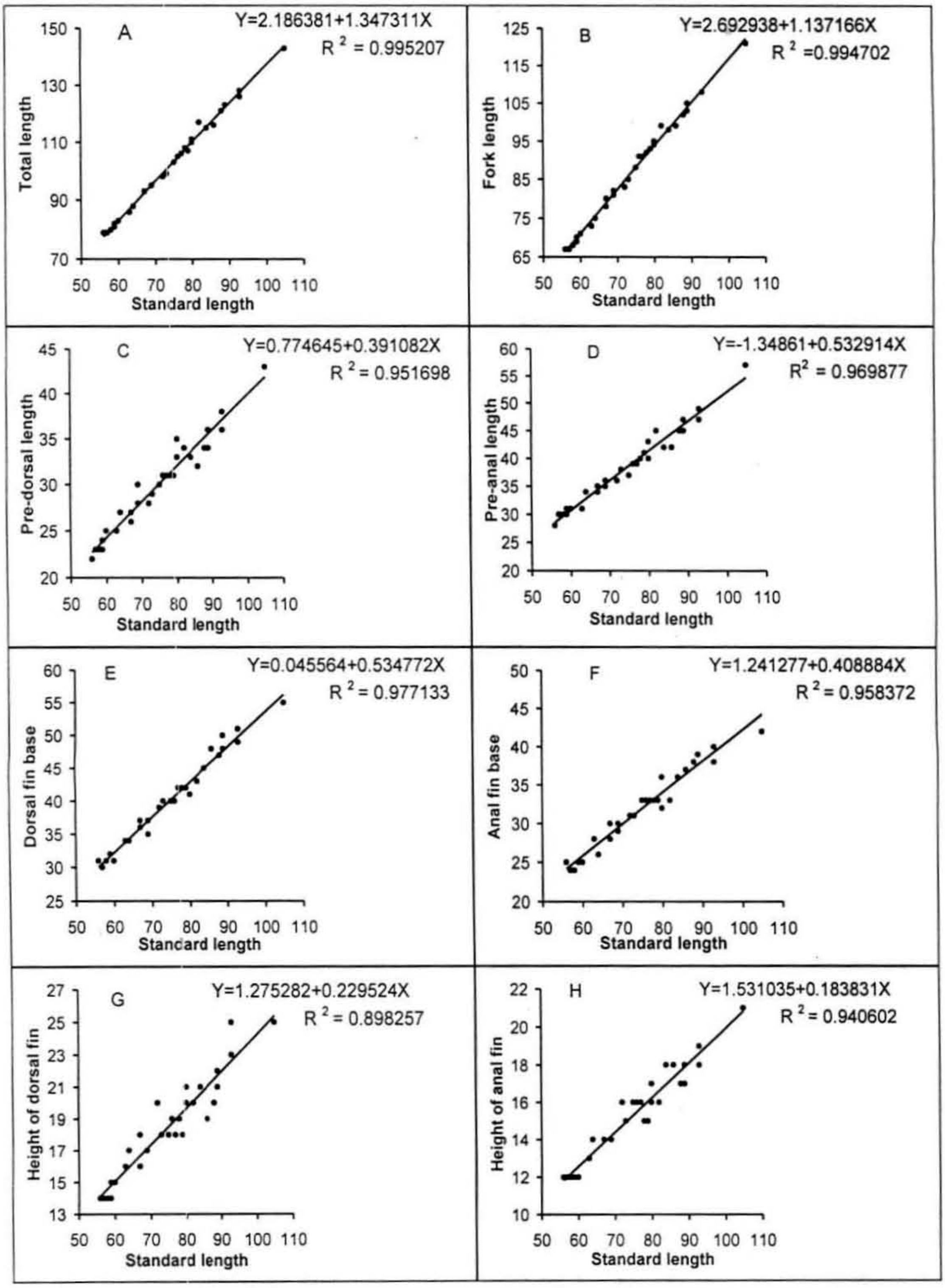



Figure 9

*L.equulus:*

Regression of A) Total length on Standard length B) Fork length on Standard length.
C) Predorsal length on Standard length D) Preanal length on Standard length.
E) Dorsal fin base on Standard length F) Anal fin base on Standard length.
G) Height of dorsal fin on Standard length H) Height of anal fin on Standard length.

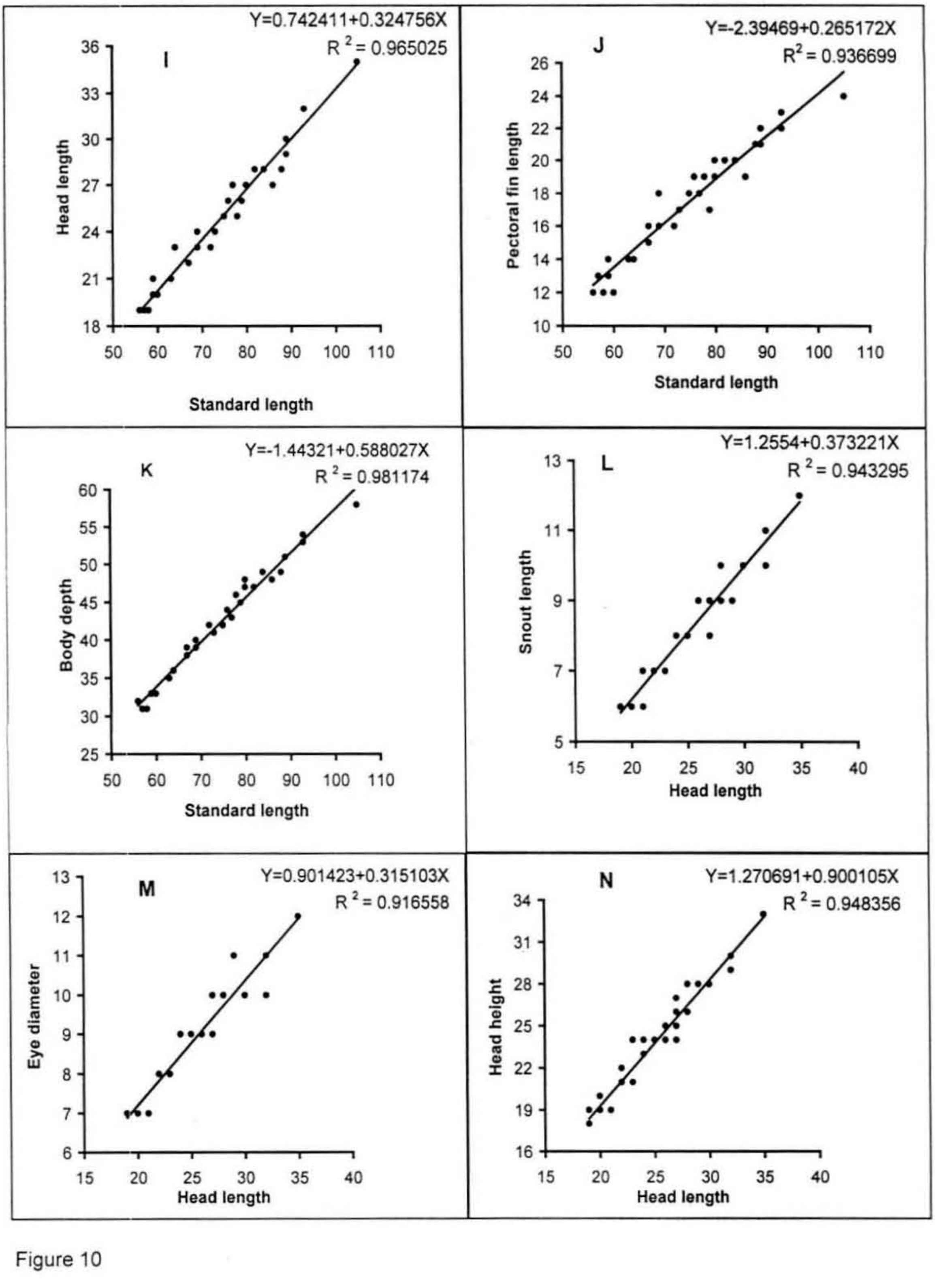



Figure 10

*L.equulus:*

Regression of I)Head length on Standard length J) Pectoral length on Standard length.
K) Body depth on Standard length L) Snout length on Head length.
M) Eye diameter on Head length N) Head height on Head length.

### 5. *Leiognathus dussumieri* (Valenciennes, 1835)

(Plate I, Fig. 5; Figures 11-12; Tables 1-3)

*Equula dussumieri* Valenciennes 1835, in Cuvier & Valenciennes, *Hist. Nat. Poiss.*, **10** : 77.

*Material examined:* 30 specimens (8 females, 13 males, 9 indeterminates) ranging from 71 mm to 130 mm total length from Cochin and Neendakara.

DESCRIPTION:

D.VIII, 16; P. ii, 14-15, i – iii; V. I, 5; A. III, 14; C. 15; Ll. 51-60.

*As percent of standard length:* Total length 131.31-137.84 (134.70); fork length 115.05-118.97 (116.58); predorsal 35.71-38.46 (37.14); preanal 46.43-53.54 (50.27); dorsal base 55.26-58.21 (56.81); anal base 40.40-45.61 (43.37); head 29.82-34.21 (31.74); dorsal height 17.54-26.87 (23.65); anal height 14.55-20.55 (18.00); pectoral 19.18-23.29 (20.91); depth 43.21-49.49 (46.97).

*As percent of head length:* Snout 23.53-34.48 (29.49) ; eye 30.77-40.91 (34.07); head height 76.92-88.24 (81.01).

Body oblong, moderately compressed, dorsal and ventral profiles equally convex. Dorsal profile elevated and curved behind occipital profile and separated from it by a gentle concavity. Snout blunt Mouth small and when protracted directed downwards. Commencement of gape of mouth below lower margin of eye. Mandibles slightly concave inferiorly. Teeth small, numerous, villiform, in each jaw. Two small spines on top of the head, opposite the front border of the eye. Pre-opercle with its lower margins finely serrated. Lateral line begins with a concavity and runs less convex than the dorsal profile, extending beyond the end of the soft dorsal and anal fins, but stops just short of the base of the caudal fin. Ventrals do not quite reach the anals, stopping just short. Ventrals with a strong spine and a large axillary scale. Caudal forked with rounded lobes.

COLOUR: Abdomen silvery, back brownish. Sides of body with dark, narrow, wavy vertical lines descending from the back to a little beyond lateral line, often fading on keeping in formalin. An elongate yellow spot on belly below pectoral fin. Base of pectoral fin dark.

DISTRIBUTION: It is known from off Cochin, Quilon, Tuticorin, Pamban, Mandapam, Kakinada, and Visakhapatnam. It is most dominant in southern Tamilnadu, in the Gulf of Mannar off Mandapam, Tuticorin and Pamban.

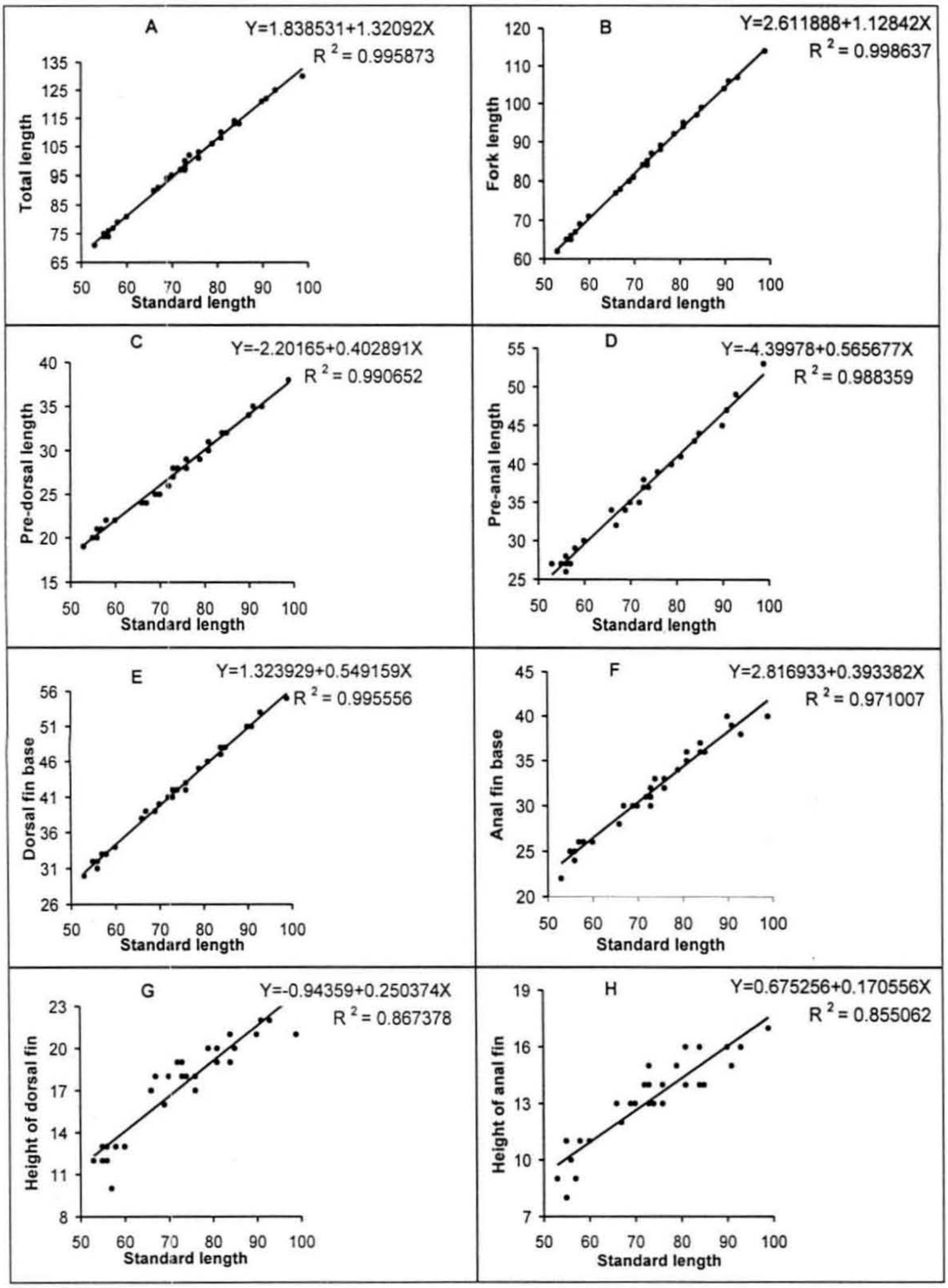



Figure 11

*L.dussumieri:*

Regression of A) Total length on Standard length B) Fork length on Standard length.
C) Predorsal length on Standard length D) Preanal length on Standard length.
E) Dorsal fin base on Standard length F) Anal fin base on Standard length.
G) Height of dorsal fin on Standard length H) Height of anal fin on Standard length.

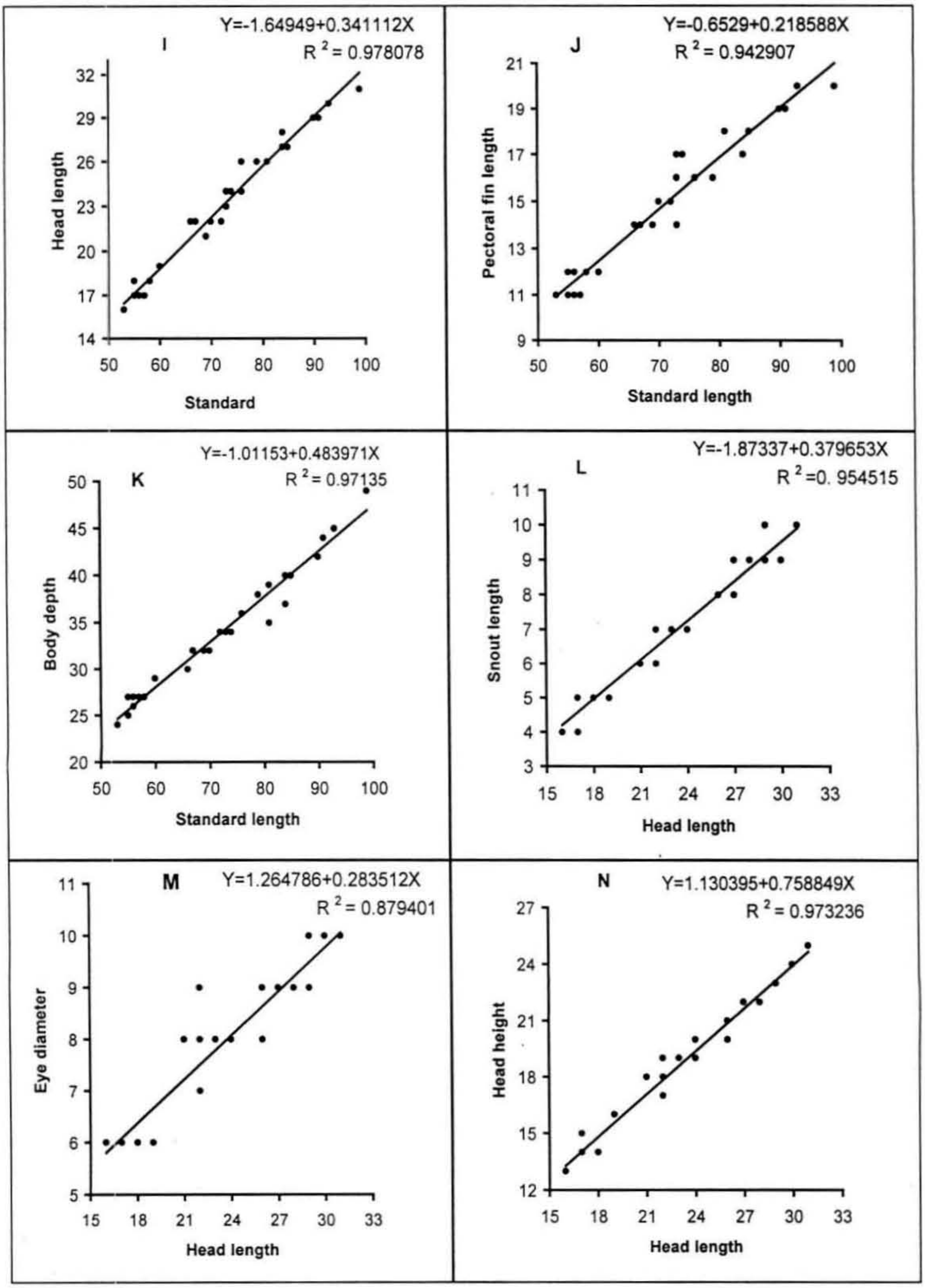



Figure 12

*L.dussumieri:*

Regression of I) Head length on Standard length J) Pectoral length on Standard length.
K) Body depth on Standard length L) Snout length on Head length.
M) Eye diameter on Head length N) Head height on Head length.

## *6. Leiognathus daura (Cuvier, 1829)*

(Plate I, Fig. 6; Figures 13-14; Tables 1-3)

*Equula daura* Cuvier, 1829, *Regne Anim.*,2 : 212.

*Material examined* 10 specimens (2 females, 3 males, 5 indeterminates) ranging from 56 mm to 136 mm total length from Cochin and Neendakara.

DESCRIPTION:

D.VIII, 16; P. ii, 14-16, i-iii; V. I, 5; A. III, 14; C. 15; Ll. 64-69.

*As percent of standard length:* Total length 130.23-135.63 (133.54); fork length 113.46-116.67 (114.68) predorsal 37.04-40.59 (38.89); preanal 47.92-54.46 (50.66); dorsal base 52.08-55.00 (53.45); anal base 39.60-45.83 (42.62); head 26.79-30.77 (28.70); dorsal height 18.60-25.29 (20.97); anal height 13.86-17.24 (15.03); pectoral 16.28-19.80 (18.18); depth 37.21-47.52 (42.33).

*As percent of head length:* Snout 25.00-31.25 (28.60); eye 30.77-39.13 (34.22); head height 78.57-88.0 (83.18).

Body elongated and compressed. Dorsal and ventral profiles equally convex. Occipital region with a concavity and the dorsal profile rises from this region to the spinous dorsal. Snout blunt. Mouth small with thick broad lips and pointing downwards when protracted. Commencement of gape of mouth opposite lower one third of the eye. Inferior margin of the lower jaw slightly concave. Pre-opercle with its lower margin finely serrate. Teeth small and numerous, on both the jaws. Two small spines on top of the head, opposite the front border of the eye, the outer one more prominent than the inner which is opposite the ridge bounding the interorbital space. First part of the lateral line with a concavity, later running less convex than the dorsal profile, extending posteriorly to the base of the caudal fin. Ventrals with a strong spine and a large axillary scale and do not reach the anal fin. Caudal forked.

COLOUR: Abdomen silvery and back grey. Black dots all over the ventral half of the body. Tip of snout black. Inner side of pectoral base grey. A deep black blotch on the upper half of the spinous dorsal, extending from the posterior margin of the second dorsal spine to the anterior margin of the sixth dorsal spine. A broad yellow band over the lateral line from the posterior margin of the eye to the caudal base, distinct in fresh specimens, but disappearing gradually on keeping in formalin. Anal fin golden yellow from the second spine onwards along the distal half of the fin. A black line running along the the base of the soft dorsal.

DISTRIBUTION: Along Goa, Cochin and Quilon along the west coast of India and Palk Bay, Gulf of Mannar, Chilka lake, Kakinada and Porto Novo along the east coast.

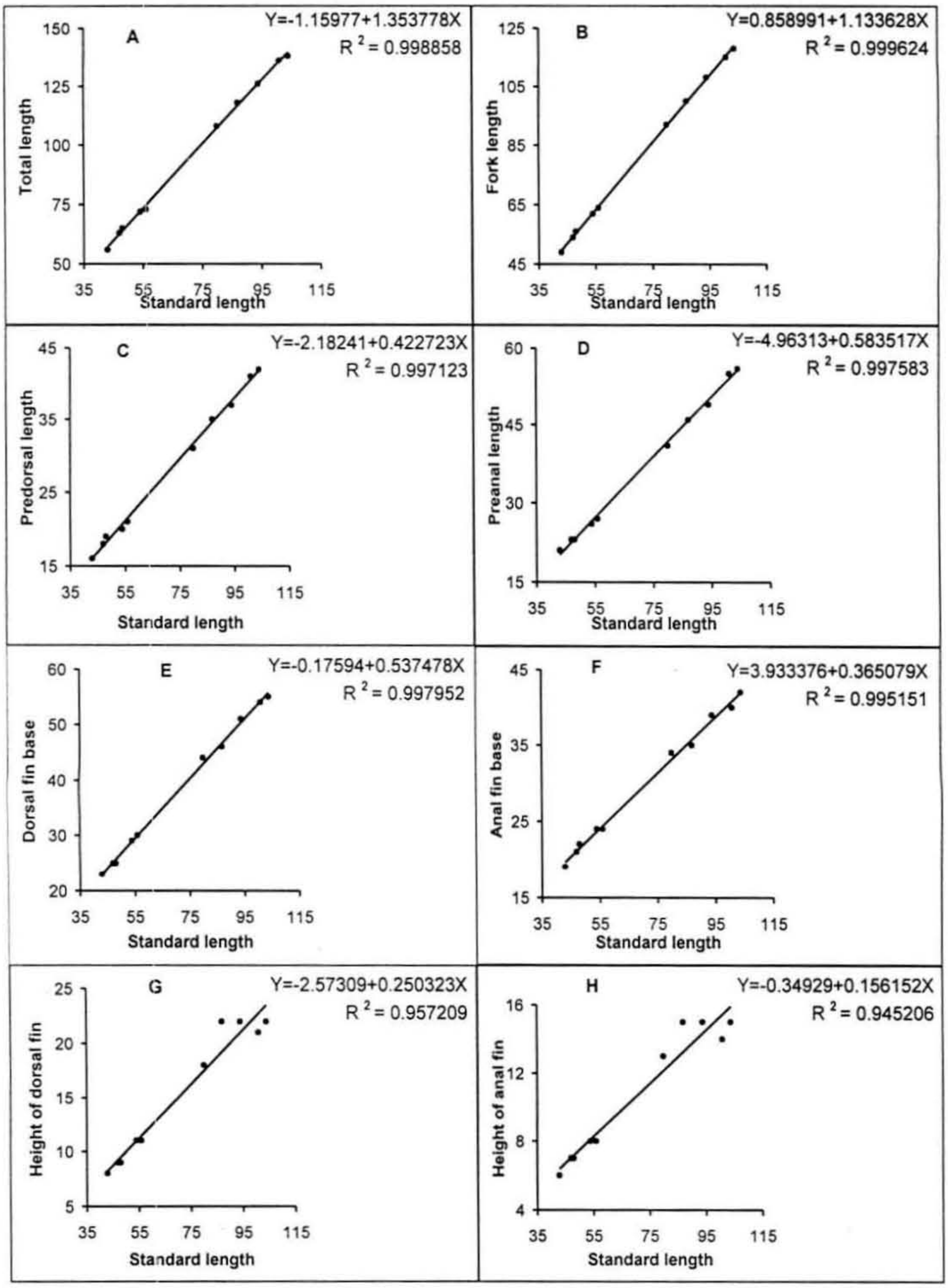



Figure 13

*L.daura:*

Regression of A) Total length on Standard length B) Fork length on Standard length.
C) Predorsal length on Standard length D) Preanal length on Standard length.
E) Dorsal fin base on Standard length F) Anal fin base on Standard length.
G) Height of dorsal fin on Standard length H) Height of anal fin on Standard length.

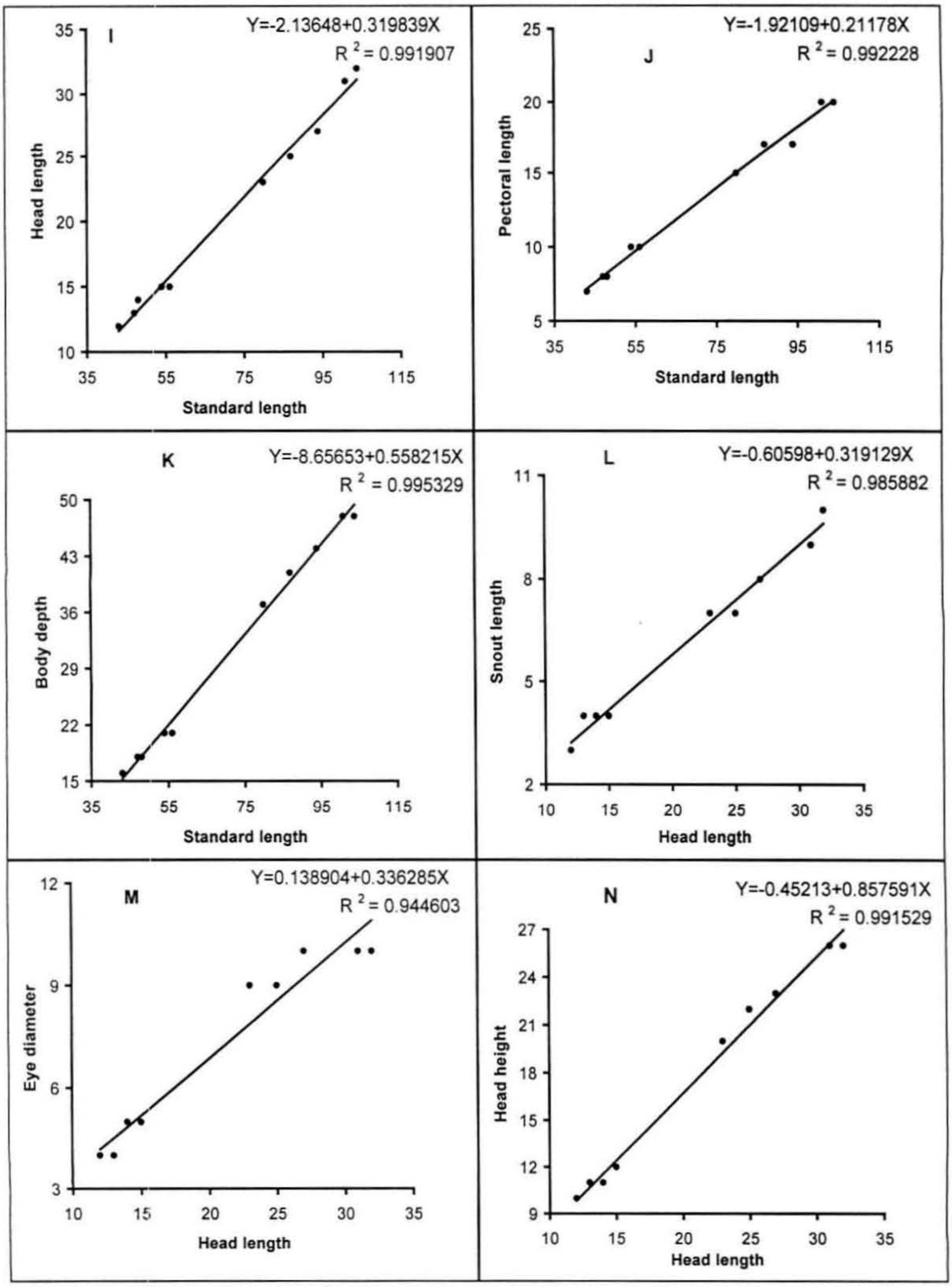



Figure 14

*L.daura:*

Regression of I) Head length on Standard length J) Pectoral length on Standard length.
K) Body depth on Standard length L) Snout length on Head length.
M) Eye diameter on Head length N) Head height on Head length.

## 7. *Leiognathus blochi* (Valenciennes, 1835)

(Plate I, Fig. 7; Figures 15-16; Tables 1-3 )

*Equula blochii* Valenciennes, in Cuvier and Valenciennes, 1835, *Hist. Nat. poiss.*, 10 : 84.

*Material examined*: 30 specimens (11 females, 10 males, 9 indeterminates) ranging from 71 mm to 94 mm total length from Cochin and Neendakara.

DESCRIPTION

D.VIII, 15-16; P. ii, 12-14, i-iii; V. I, 5; A.III, 14; C. 15. Ll. 49-57.

*As percent of standard length*: Total length 131.34-136.54 (133.74); fork length 112.96-118.75 (115.78); predorsal 34.55-38.89 (36.78); preanal 46.55-52.24 (49.74); dorsal base 55.07-58.18 (56.17); anal base 40.30-44.62 (43.10); head 27.59-31.03 (29.28); dorsal height 19.70-24.07 (21.93); anal height 17.91-21.74 (19.57); pectoral 17.91-23.08 (20.45); depth 36.21-42.59 (39.72).

*As percent of head length*: Snout 22.22-30.00 (25.98); eye 27.78-37.50 (32.58); head height 80.00-88.89 (84.24).

Body oval, compressed, rather elongate. Dorsal and ventral profiles almost equally convex, the former evenly curved from tip of snout to origin of dorsal fin. Snout pointed. Mouth small, lips narrow and thin. Mouth when protracted forms a tube directed downwards. Gape of mouth opposite lower third of eye. Lower jaw strongly concave. Teeth small, numerous, villiform, in each jaw. Two small spines on top of the head opposite front border of the eye. Pre-opercle with a finely serrated lower margin. First part of the lateral line shows concavity, later running less convex to the dorsal profile, extending posteriorly to the base of the caudal fin. Ventrals not reaching half way to the anals and with axillary scales. Caudal deeply forked.

COLOUR: Abdomen more silvery than back, with black irregular bands extending to about half level. Light brown blotch on nape, which covers an area from about the posterior half of the nuchal spine to the origin of the dorsal fin. Membrane from above the half level to the tip of spines between the second to the seventh dorsal spines black. Tip of snout dotted black. Fine black dots on ventral half of the body. Inner side of the pectoral, posteriorly dark coloured. Gill opening area covered by the lower half of the operculum also dotted black.

DISTRIBUTION: Known from off Madras, Kakinada, Calcutta and in Sunderbans and Chilka Lake.

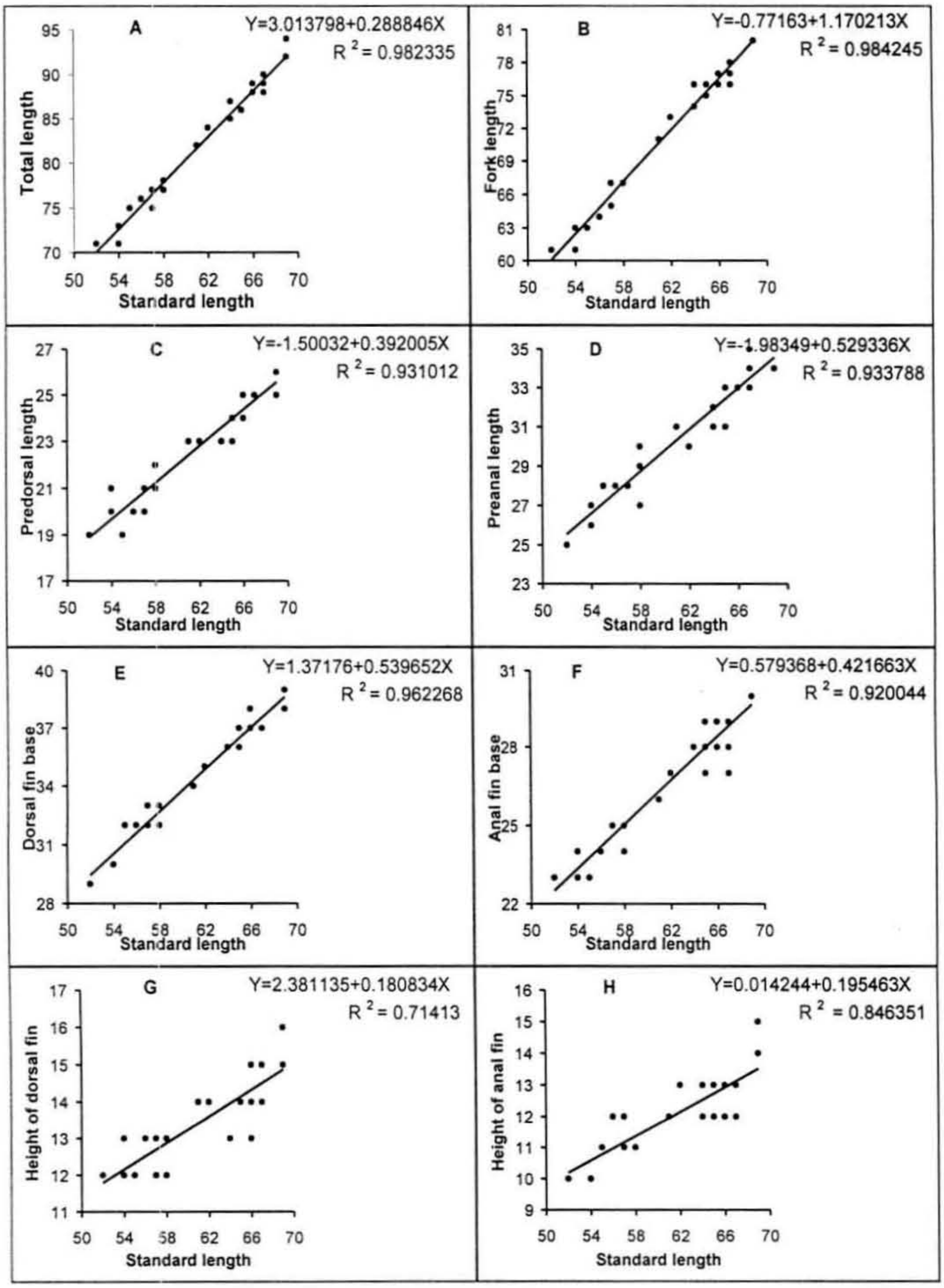



Figure 15

*L.blochi:*

Regression of A) Total length on Standard length; B) Fork length on Standard length.
C) Predorsal length on Standard length; D) Preanal length on Standard length.
E) Dorsal fin base on Standard length; F) Anal fin base on Standard length.
G) Height of dorsal fin on Standard length; H) Height of anal fin on Standard length.

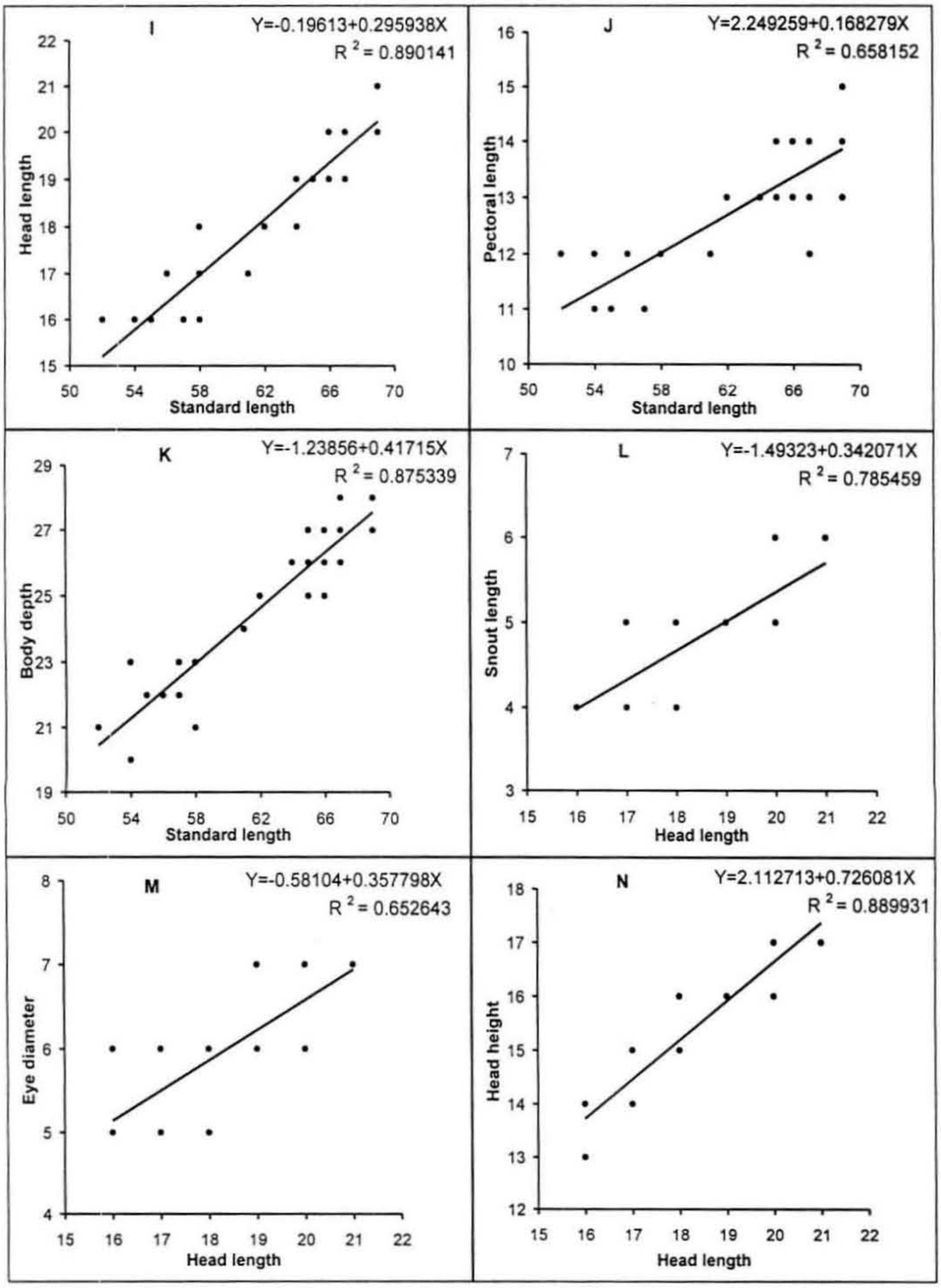



Figure 16

*L.blochi:*

Regression of I) Head length on Standard length J) Pectoral length on Standard length.
K) Body depth on Standard length L) Snout length on Head length.
M) Eye diameter on Head length N) Head height on Head length.

### *8. Leiognathus lineolatus* (Valenciennes, 1835)

(Plate I, Fig. 8; Figures 17-18; Tables 1-2)

*Equula lineolata* Valenciennes in Cuvier and Valenciennes, 1835, *Hist. nat. Poiss.*, **10**: 86.

*Material examined:* 10 specimens (2 females, 4 males, 4 indeterminates) ranging from 54 mm to 76 mm total length.

DESCRIPTION:

D.VIII, 16; P. ii, 11-12, ii; V. I, 5 ; A. III , 14 ; C. 15 .

*As percent of standard length*: Total length 128.81-132.00 (130.48); fork length 112.77-116.07 (114.52); predorsal 35.42-37.50 (36.49); preanal 46.67-50.00 (48.67); dorsal base 55.36-59.57 (57.04); anal base 42.55-45.83 (44.18); head 26.67-29.17 (27.87); dorsal height 15.56-18.00 (17.06); anal height 12.20-14.58 (13.13); pectoral 16.67-18.00 (17.29); depth 31.71-40.00 (36.97).

*As percent of head length*: Snout 21.43-31.25 (26.62) ; eye 31.25-38.46 (34.00) ;head height 71.43-81.82 (76.17).

Body oblong, compressed and elongate, dorsal and ventral profiles equally convex. A slight concavity over occiput. Snout pointed. Mouth small, lips narrow and thick. Mouth when protracted forms a tube directed downwards. Commencement of gape of mouth over lower one third of eye. Inferior edge of mandibles slightly concave. Teeth small, numerous, on the jaws. A pair of spines on top of the head, over the anterior third of the orbit. Pre-opercle with its lower margin straight and finely serrated. First part of lateral line with a concavity, later running less convex to the dorsal profile, and cannot be traced forward from somewhere between the middle to the end of the dorsal fin, posteriorly. Ventrals with axillary scale and their tips does not quite reach the origin of the anals. Caudal fin deeply forked.

COLOUR: Belly silvery, back brownish with relatively sparse vertical zigzag lines or grey irregular vermiculations from behind head to caudal base, laterally extending down to a little below the lateral line. Ventral half of the body with fine black dots. Tip of snout dotted black. Inner side of pectoral base also dotted black, as also the lower edge of the gill opening covered by the opercular flap.

DISTRIBUTION: Along Cochin, Quilon, Palk Bay and Gulf of Mannar, Madras, and Kakinada.

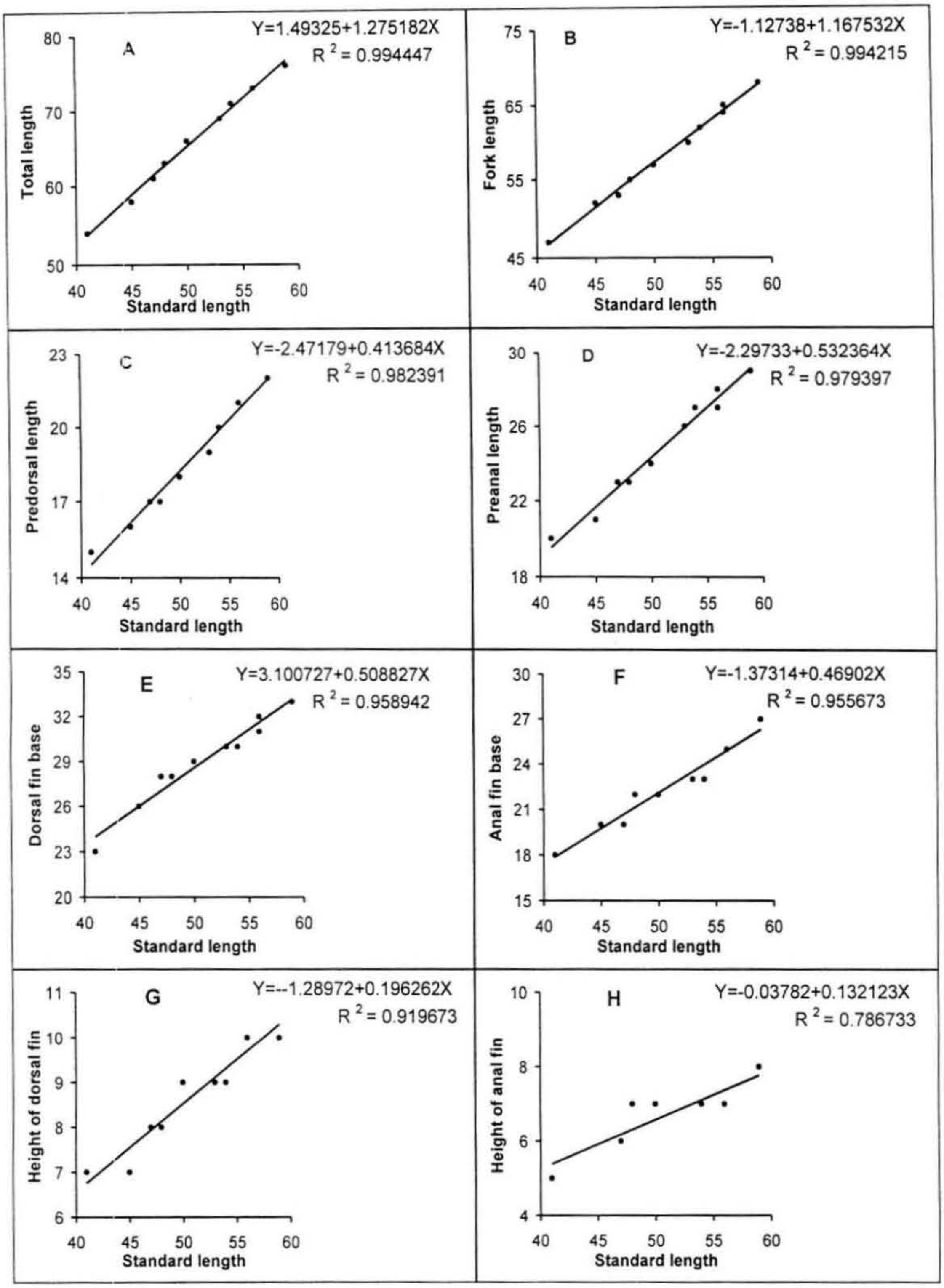



Figure 17

*L.lineolatus:*

Regression of A) Total length on Standard length; B) Fork length on Standard length.
C) Predorsal length on Standard length; D) Preanal length on Standard length.
E) Dorsal fin base on Standard length; F) Anal fin base on Standard length.
G) Height of dorsal fin on Standard length; H) Height of anal fin on Standard length.

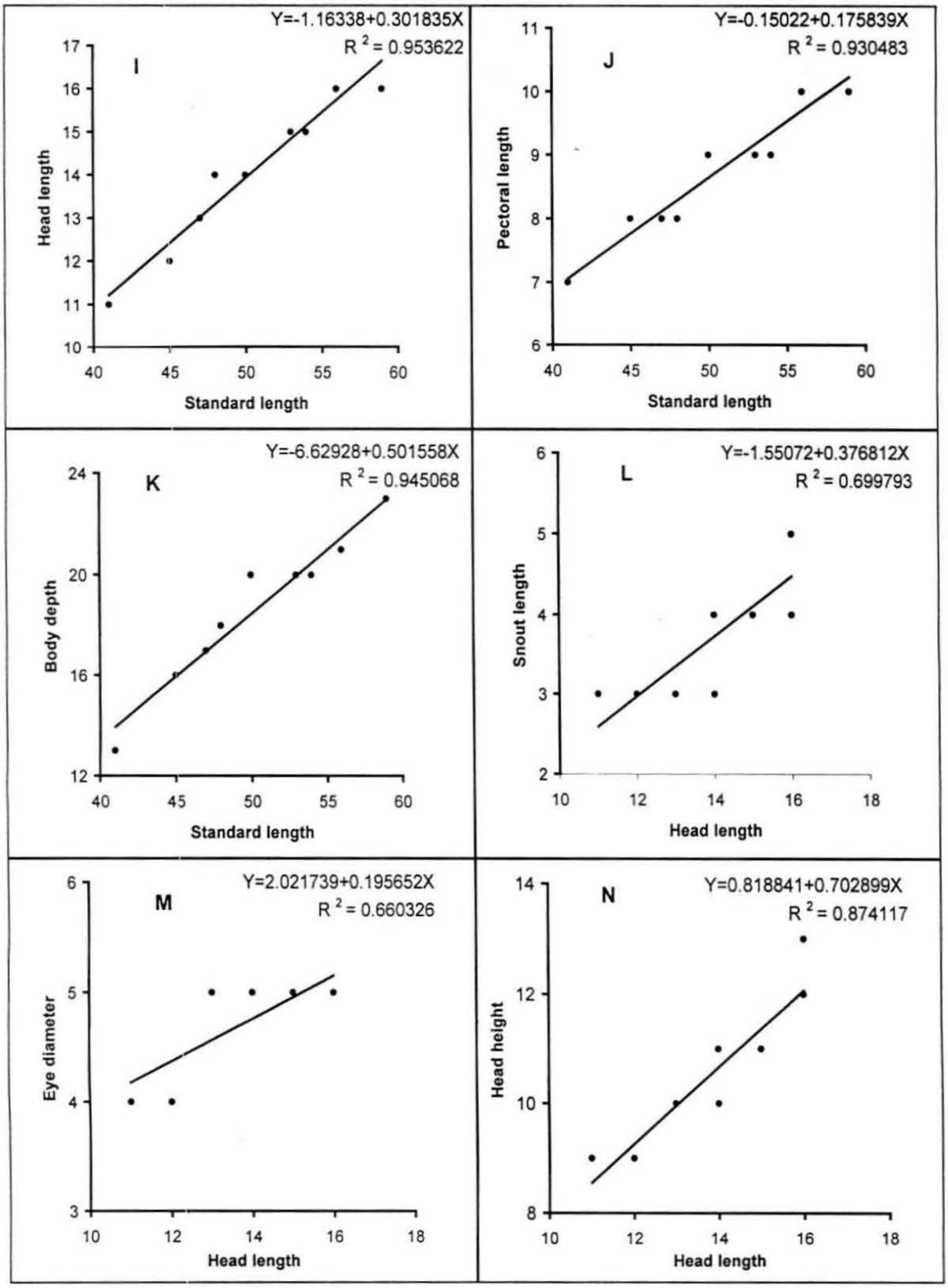



Figure 18

*L.lineolatus:*

Regression of I) Head length on Standard length J) Pectoral length on Standard length.
K) Body depth on Standard length L) Snout length on Head length.
M) Eye diameter on Head length N) Head height on Head length.

## 9. *Leiognathus leuciscus* (Gunther, 1860)

(Plate II, Fig. 1; Figures 19-20; Tables 1-3)

*Equula leuciscus* Gunther, 1860. *Cat. Brit. Mus.*, 2: 503.

*Material examined:* 10 specimens (5 females, 4 males, I in determinant) ranging from 77 mm to 134 mm from Cochin and Neendakara.

DESCRIPTION:

D.VIII, 16; P. ii, 13-14, iii; V. I, 5; A. III, 14; C. 15; Ll. 61-64.

*As percent of standard length:* Total length 128.77-135.09 (131.37); fork length 113.04- 116.28 (114.40); predorsal 36.23-38.46 (37.37); preanal 49.12-55.77 (50.92); dorsal base 54.10-58.14 (55.88); anal base 38.46-44.26 (42.24); head 26.25-28.85 (27.87); dorsal height 21.05-27.54 (24.72); anal height 15.79-20.51 (17.52); pectoral 15.94-17.91 (16.71); depth 36.07-41.86 (39.06).

*As percent of head length*: Snout 28.57-33.33 (30.41); eye 29.17-37.50 (32.58); head height 76.19-85.71 (79.78).

Body compressed and elongate. Dorsal profile somewhat more convex than the ventral. Upper profile of head rises back with a little concavity. Snout pointed. Mouth small pointing downwards when protracted. Cleft of mouth opposite middle to lower third of eye. Mandibular profile slightly concave. Two spines on the supraorbital edge of the eye. Villiform teeth present in each jaw. Lateral line extends beyond soft dorsal and anal fins, up to the base of the caudal fin. Second dorsal spine elongated and filiform, upper half of which is flexible. The second dorsal spine when flexed backwards extends up to the second to the fourth dorsal ray (only 3 specimens examined for this character, since in all the others the second dorsal spine was broken), i.e. well in front of the middle of the soft dorsal. The third dorsal spine is only about half the length of the preceding. The anal fin commences vertically below the eighth dorsal spine. Ventral fins reaching only to about two-thirds of the distance to the anal fin origin. Caudal forked.

COLOUR: Body silvery, back and sides marked with a number of irregular semicircular and undulated, dark, grey–brown spots and vermiculations. Yellow spots below lateral line on large specimens, fading almost completely on preservation in formalin. Pectoral axil, black with minute dots. Membrane between dorsal fin spines soft yellow at mid height, edge of soft part of dorsal fin also yellow. Posterior part of caudal fin also yellowish.

DISTRIBUTION: Distributed off Palk Bay, Gulf of Mannar and Madras.

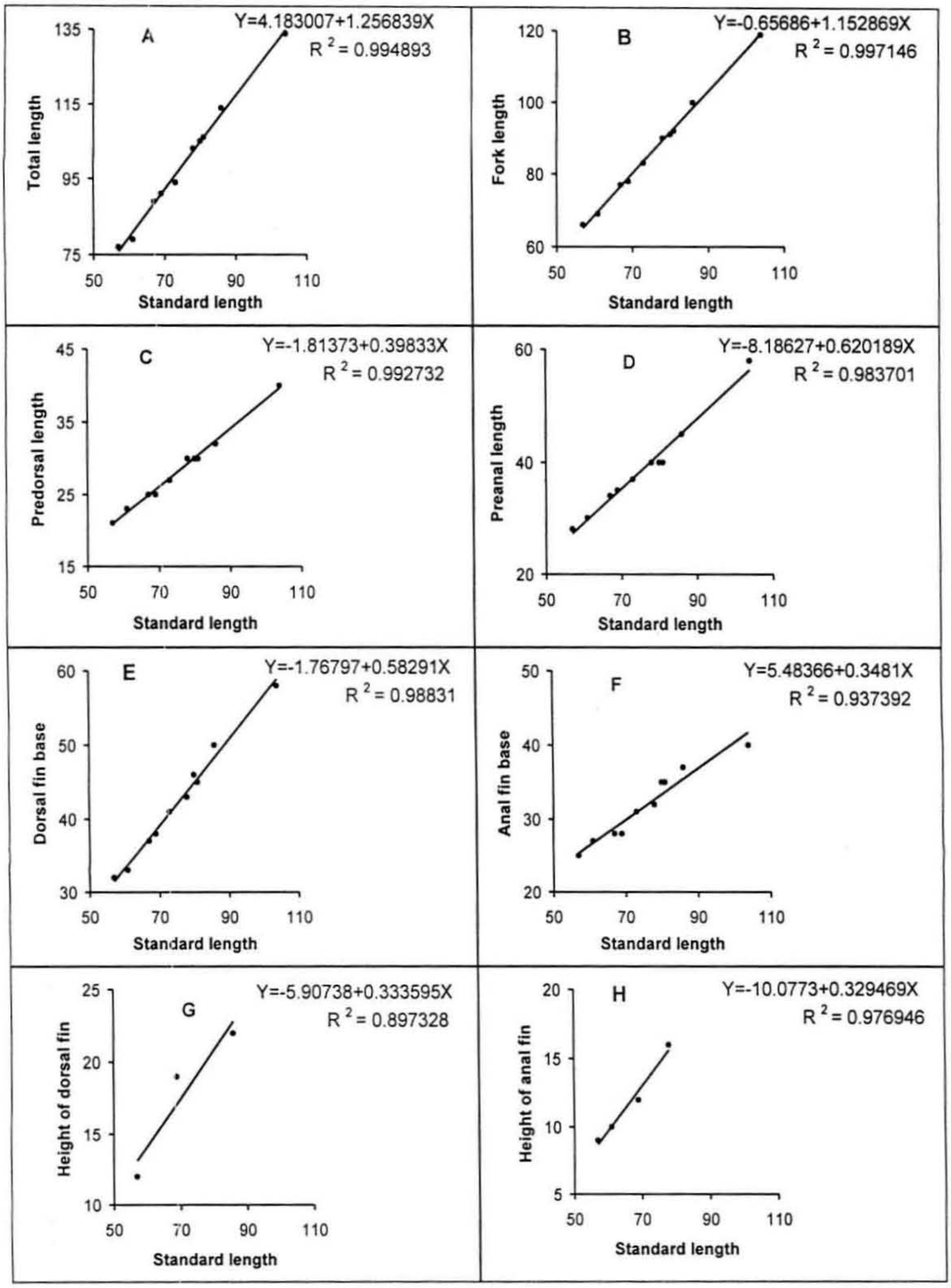



Figure 19

*L.leuciscus:*

Regression of A) Total length on Standard length B) Fork length on Standard length.
C) Predorsal length on Standard length D) Preanal length on Standard length.
E) Dorsal fin base on Standard length F) Anal fin base on Standard length.
G) Height of dorsal fin on Standard length H) Height of anal fin on Standard length.

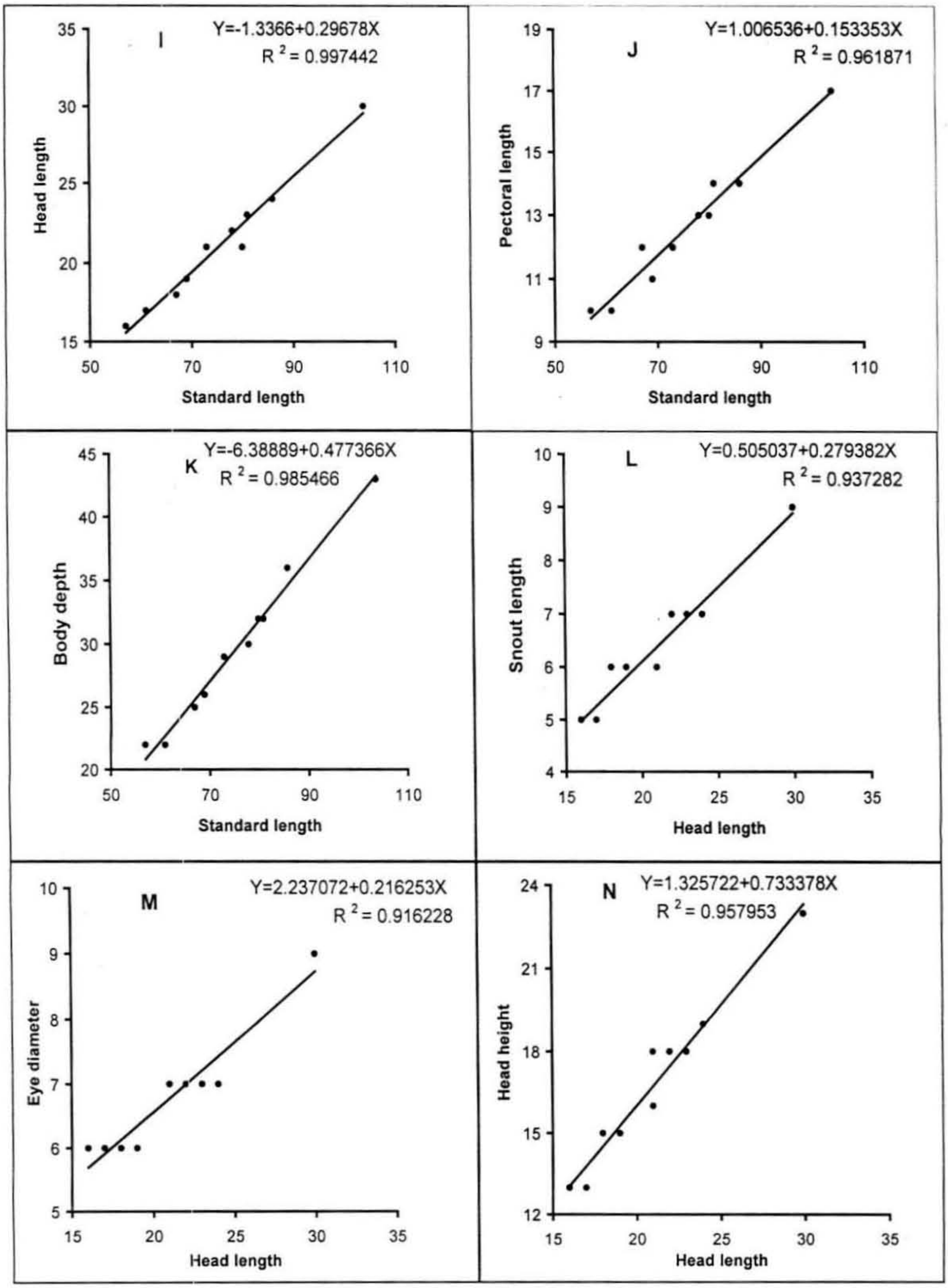



Figure 20

*L.leuciscus:*

Regression of I) Head length on Standard length J) Pectoral length on Standard length.
K) Body depth on Standard length L) Snout length on Head length.
M) Eye diameter on Head length N) Head height on Head length.

### *10. Leiognathus fasciatus* (Lacepede, 1803)

(Plate II, Fig. 2; Table 1-3)

*Clupea fasciata* Lacepede, 1803, Hist. Nat. Poiss., 5: 460,463

*Material examined*: 3 specimens (2 males, 1 indeterminate) ranging from 111 mm to 129 mm standard length from Cochin and Neendakara.

DESCRIPTION:

D.VIII, 16; P. ii, 14-16, ii; V. I, 5; A. III, 14; C. 15. Ll. 62.

*As percent of standard length*: Total length 134.48-136.04 (135.26); fork length 113.79-115.32; predorsal 38.76-39.64 (39.06); preanal 49.61-52.59 (51.48); dorsal base 55.17-55.86 (55.61); anal base 41.38-44.96 (43.19); head 31.01-32.43 (31.49); dorsal height 39.66; anal height (20.93); pectoral 22.41-22.52 (22.47); depth 54.95-56.59 (55.57).

*As percent of head length*: Snout 33.33-35.00 (33.89); eye 35.00-36.11; head height 86.11-91.67 (88.43).

Body compressed, ovate and deep. Back more strongly arched than anterior part of belly. Mouth horizontal and when protracted forming a tube with downward direction. Gape of mouth when closed opposite and below the lower margin of the eye. Mandible slightly concave inferiorly. Narrow band of villiform teeth in each jaw. A pair of spines above the anterior superior angle of the orbit. Pre-opercular with its lower margin finely serrated. Lateral line, very slightly concave at commencement and convex thereafter, but less so when compared to the dorsal profile, and extends up to a little distance short of the base of the caudal fin. Second dorsal spine filiform, its tip extending up to the origin of the eighth dorsal ray, when flexed backward (only one specimen examined for this character). Second anal spine somewhat elongate, but not as long as the second dorsal. Ventrals with prominent axillary scale (its tip reaching the tip of the innermost rays). Ventrals does not reach the origin of the anal. Caudal deeply forked.

COLOUR: Abdomen and back silvery. Upper half with indistinct grey-brown vertical bands descending up to a little beyond the lateral line, numbering ten to fifteen. In between lateral line and median line of the body a few big oval yellow blotches are present in addition to a few smaller ones of the same hue. Inner side of pectoral base dotted black. Spinous anal fin with faint yellow colouring, continued marginally along the rays. Caudal fin dusky.

DISTRIBUTION: Along Cochin, Quilon, Gulf of Mannar and Palk Bay. It does not form a fishery of any importance anywhere along the coast.

### 11. ***Leiognathus smithursti*** **(Ramsay and Ogilby, 1886)**

(Plate II, Fig. 3; Tables 1-3)

*Equula smithursti* Ramsay & Ogilby, 1886, *Proc. Linn. Soc. N. S. Wales* (2) **1**: 11.

*Material examined:* 1 specimen , male , 115 mm in total length from Cochin.

DESCRIPTION

D.VIII, 16; P. ii, 17, ii; V. I, 5; A. III, 14; C. 15. Ll. 61.

*As percent of standard length*: Total length 133.72; fork length 117.44; predorsal 37.21; preanal 51.16; dorsal base 58.14; anal base 44.19; head 30.23; dorsal height 41.86; anal height 45.35; pectoral 22.09; depth 56.98.

*As percent of head length*: Snout 30.77; eye 34.62 ; head height 92.31.

Body oval and compressed. Anterior part of the dorsal profile more strongly arched than anterior part of the ventral profile. The upper profile of the head with a gentle concavity. Snout blunt. Mouth small and pointing downward when protracted. Cleft of mouth above lower edge of eye. Mandibles inferiorly slightly concave. Teeth small, numerous and villiform. Two small spines above the anterior superior angle of the orbit. Pre-operculum with its lower margin distinctly and finely serrated. Lateral line strongly convex, extends beyond end of soft dorsal and anal, but stops a short distance in front of the caudal fin. Second spines of dorsal and anal fin greatly elongated. The second dorsal spine reaches up to the sixth dorsal ray and the ventral spine up to the fifth dorsal ray (only one specimen examined).

COLOUR: Abdomen more silvery than back, which shows a few, faint, unevenly spaced horizontally elongate grey brown streaks or blotches. Variable number of yellow blotches along the flank below the lateral line. Soft anal and margin of soft dorsal fin yellow. Underside of the pectoral fin base dotted black. Tip of snout grey. Margin of caudal lobes dusky.

DISTRIBUTION: Only stray catches are reported from Palk Bay and Kakinada. Reported from Cochin for the first time, in the present work.

## 12. *Leiognathus elongatus* Gunther ,1874

(Plate II, Fig. 4; Tables 1-2)

*Equula elongata* Gunther, 1874, Ann. Mag. Nat. Hist., 4(14):369.

*Material examined:* 2 specimens (both indeterminates) of 71 mm and 77 mm in total length from Neendakara.

DESCRIPTION

D.VIII, 16; P. ii, 12, ii; V. I, 5; A. III, 14; C. 15.

*As percent of standard length:* Total length 126.23-126.79 (126.51); fork length 113.11-114.29 (113.70); predorsal 37.50-37.70 (37.60); preanal 52.46-53.57 (53.02); dorsal base 55.74-57.14 (56.44); anal base 40.98-41.07 (41.03); head 29.51-30.36 (29.93); dorsal height (12.50); anal height 7.14-8.20 (7.67); pectoral 14.29-16.39 (15.34); depth 21.43-24.59 (23.01).

*As percent of head length:* Snout 27.78-29.41 (28.59); eye 27.78-29.41 (28.59); head height 52.94-61.11 (57.03).

Body elongate, slender and moderately compressed. Dorsal and ventral profiles, almost evenly curved and tapering gently to the very short caudal peduncle. Upper surface of head weakly convex. Snout sharp, pointed. Protracted mouth parts point downwards. Narrow band of small teeth in each jaw. Mandibular slightly concave. Lateral line conspicuous at the beginning, but could not be clearly traced thereafter, for the lateral line scales to be counted. Caudal fin deeply forked. Ventrals reaching halfway to the anals.

COLOUR: Body silvery, back and sides marked with a number of irregular, dark, brownish spots and vermiculations. Underside of pectoral fin with minute dark dots. A black spot at the base of each dorsal and anal ray. Anal fin between second and third spines yellow, as also the margin of the anterior part of the fin. Lower half of the body covered with fine black dots on the sides, the dots on the upper half of the body minute, but just as numerous.

Edge of the gill opening on the lower side, covered by the opercular flap also dotted black.

DISTRIBUTION: Occurs only in stray catches along the coast.

## GENUS 2 *SECUTOR* GISTEL, 1848

(Type species: *Zeus insidiator* Bloch, 1787)

### 13. *Secutor insidiator* (Bloch, 1787)

(Plate II, Fig. 5; Figures 21-22; Tables 1-2)

*Zeus insidiator* Bloch 1787, *Ausl. Fische*, **3**: 41,pl. 192, fig.2-3.

*Material examined:* 30 specimens (14 females, 12 males, 4 indeterminates) ranging from 47 mm to 106 mm total length from Cochin and Neendakara.

DESCRIPTION

D.VIII, 16; P. ii, 13-15, i-iii; V. I , 5 ; A. III , 14 ; C. 15 .

*As percent of standard length*: Total length 127.94-134.48 (131.96); fork length 111.54-117.14 (113.89); predorsal 35.71-38.89 (37.03); preanal 42.50-46.91 (45.25); dorsal base 52.78-58.93 (56.30); anal base 46.05-51.43 (48.07); head 26.23-28.57 (27.24); dorsal height 13.89-18.18 (16.39); anal height 8.75-12.50 (10.86); pectoral 19.44-23.08 (21.48); depth 41.67-50.72 (47.48).

*As percent of head length*: Snout 20.00-28.57 (25.04); eye 29.41-40.00 (33.59); head height 110.00-122.73 (117.62).

Body oval, deep, elongated and compressed. Dorsal profile less convex than the ventral profile and the dorsal profile strongly concave in the occipital region. Snout pointed. Mouth small and oblique, when protracted forms a tube directed upwards. Gape of mouth opposite about middle of eye. Mouth small, lips broad and thin. Lower lip broader and smaller than the upper lip, which is like a loop over the lower. When mouth is closed, the mandible is almost vertical. Lower margin of the mandible slightly concave. Teeth minute, numerous and villiform. One small spine on head, immediately above the eye and opposite its front border. Lateral line shows a slight concavity at first, later running less convex to the dorsal profile extending posteriorly almost to the base of the caudal. Ventrals with axillary scales, their tips reaching only halfway to the origin of the anals. Caudal fin deeply forked.

COLOUR: Silvery, back with about ten or so black, vertical bands, formed of patches, from behind head to end of soft dorsal, laterally extending to a little below the lateral line. Abdomen with black pigment spots. Spinous dorsal fin with the membranes between the second to the sixth spines black at the upper one third portion. A black curved band from the lower margin of the eye to the posterior angle of the lower jaw. Inner side of pectoral base dotted black. Caudal fin yellowish and posterior margin of the lobes are dusky.

DISTRIBUTION: Along Mangalore, Cochin, Quilon, Mandapam, Madras, Visakhapatnam and kakinada. It forms the dominant fishery at Mangalore and contributes heavily at Madras, Kakinada and Cochin.

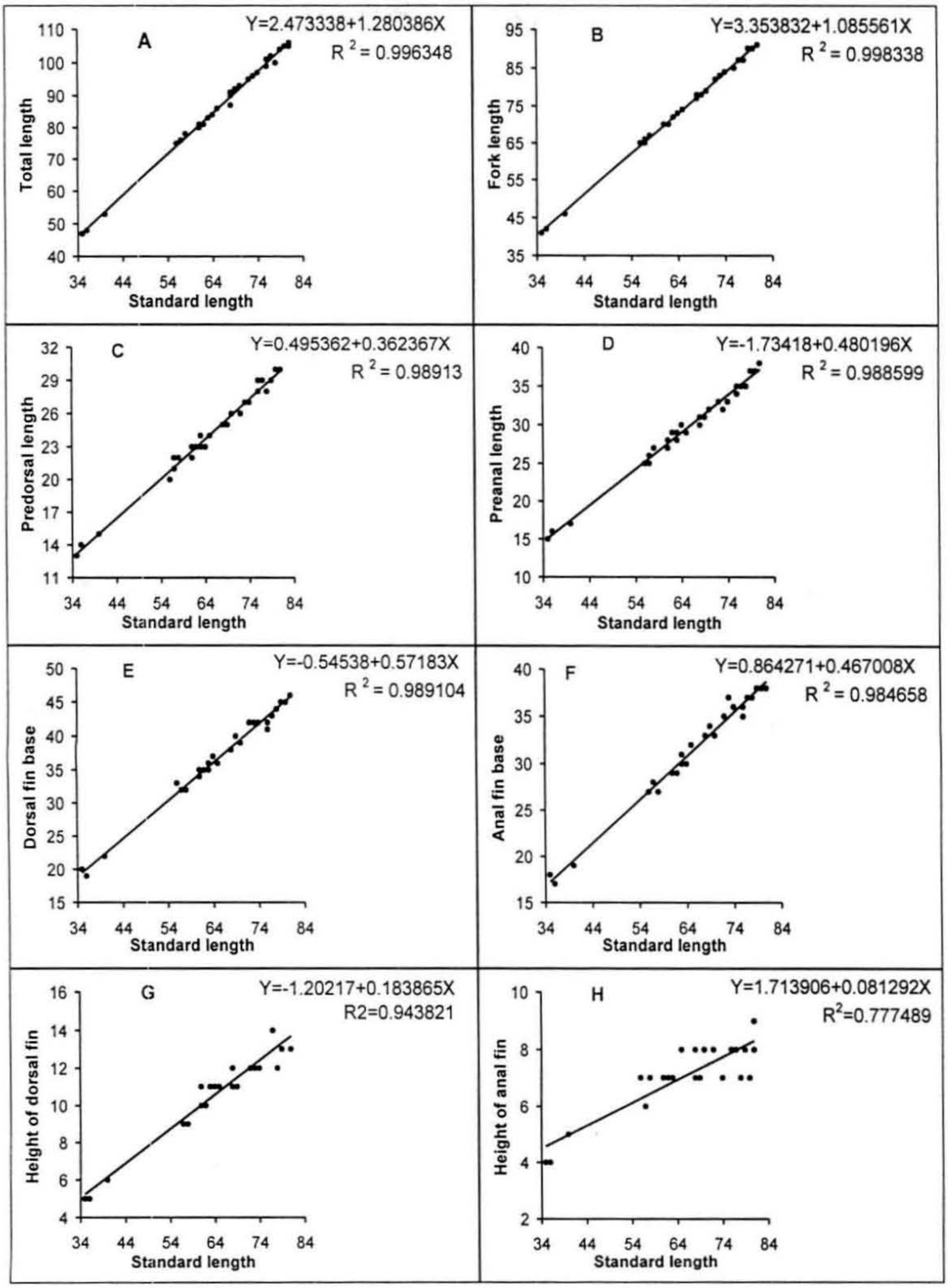



Figure 21

*S.insidiator:*

Regression of A) Total length on Standard length B) Fork length on Standard length.
C) Predorsal length on Standard length D) Preanal length on Standard length.
E) Dorsal fin base on Standard length F) Anal fin base on Standard length.
G) Height of dorsal fin on Standard length H) Height of anal fin on Standard length.

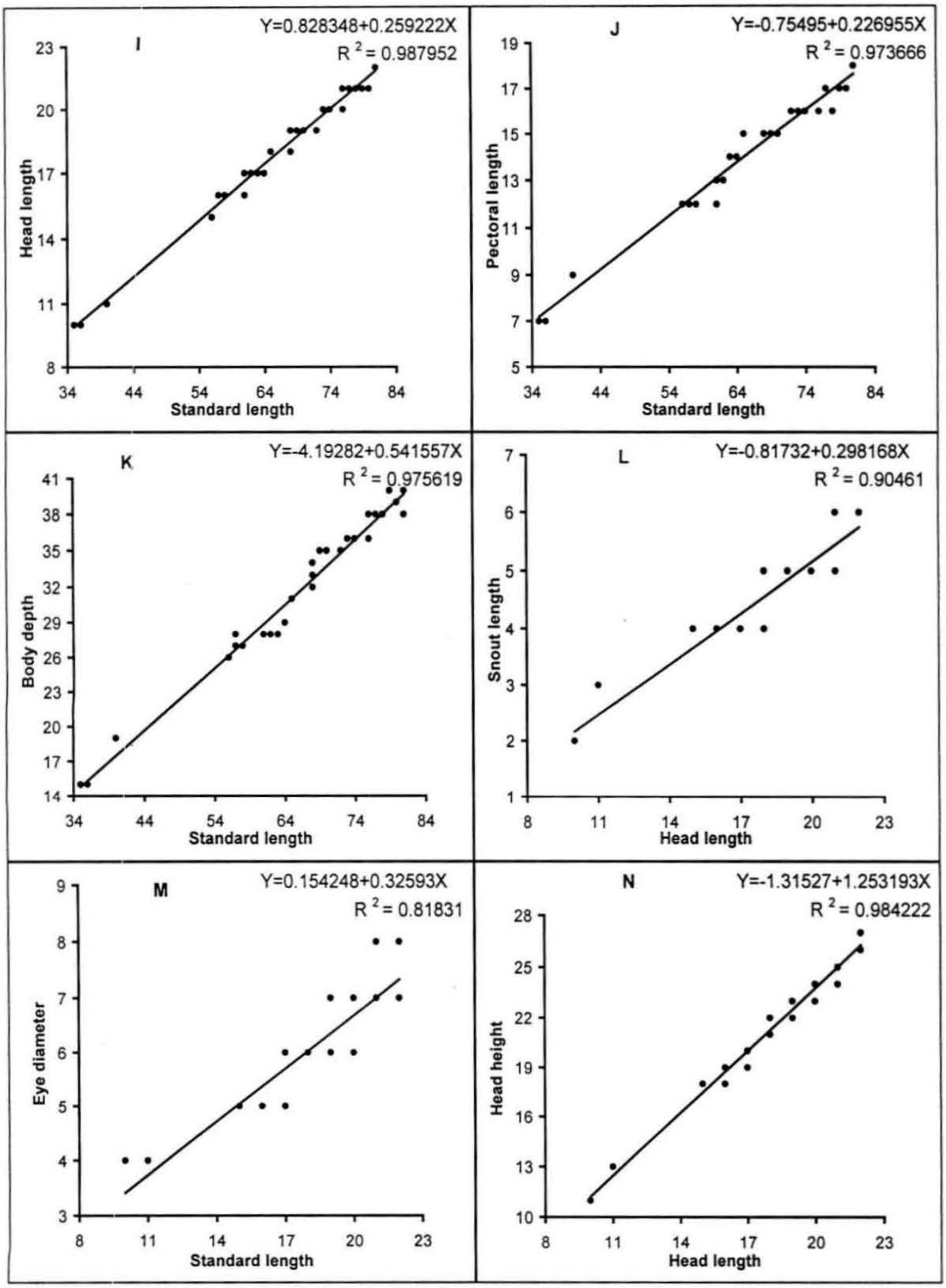



Figure 22

*S.insidiator:*

Regression of I) Head length on Standard length J) Pectoral length on Standard length.
K) Body depth on Standard length L) Snout length on Head length.
M) Eye diameter on Head length N) Head height on Head length.

## 14. *Secutor ruconius* (Hamilton-Buchanan, 1822)

(Plate II, Fig. 6; Figures 23-24; Tables 1-2)

*Chanda ruconius* Hamilton-Buchanan,1822, *Fish. Ganges*, P. 106, 371, pl.126, fig.35.

*Material examined:* 30 specimens (7 females, 9 males, 14 indeterminates) ranging from 42 mm to 83 mm from Cochin and Neendakara.

DESCRIPTION:

D.VIII, 16; P. ii, 12-14, i-ii; V. I , 5 ; A. III , 14 ; C. 15 .

*As percent of standard length*: Total length 130.77-140.00 (135.19) ; fork length 110.26-118.75 (115.28) ; predorsal 35.48-40.91 (38.28) ; preanal 40.63-47.17 (43.92) ; dorsal base 52.27-57.41 (54.87) ; anal base 46.81-51.85 (49.61) ; head 26.42-30.77 (28.93) ; dorsal height 15.63-20.37 (17.47) ; anal height 10.34-13.95 (12.19) ; pectoral 20.93- 25.00 (22.68) ; depth 56.41-62.75 (59.57).

*As percent of head length*: Snout 18.18-28.57 (24.28) ; eye 30.00-42.86 (37.15) ; head height 125.00-144.44 (134.66).

Body oval, strongly compressed and deep. Ventral profile, much more convex than the dorsal profile. Rostro-occipital line of the head concave. Mouth small, oblique, lips broad and thin, lower lip smaller and broader than the upper. Mouth when protracted forms a tube directed upwards. Gape of mouth opposite middle level of the eye. Lower margin of lower jaw slightly concave and at right angles to the mouth slit. Teeth minute, numerous and in a villiform band. One small spine on head. Pre-opercle with its lower margin finely serrate. Lateral line convex from the beginning, later runs less convex to the dorsal profile, often indistinct from the middle of the soft dorsal. Ventrals with axillary scales and do not reach even half way to the anals. Caudal deeply incised, lobes pointed.

COLOUR: Body silvery with about ten or so black or grey vertical bands on the back, extending to a little below the lateral line, anteriorly commencing below tip of the nuchal spine and posteriorly extending up to the end of the soft dorsal, and often the lines are in continuous patches. Membrane between the second and fifth dorsal spines black in the upper one third portion. A prominent curved black band running from lower margin of eye to beyond posterior angle of lower jaw. Abdomen silvery, dotted with black pigment dots. Pectoral axil dotted black.

DISTRIBUTION: Along Goa, Cochin, Quilon, Gulf of Mannar, Palk Bay, Chilka lake, Porto Novo and Godavary estuary. Among these places it is more abundant at Visakhapatnam and Kakinada.

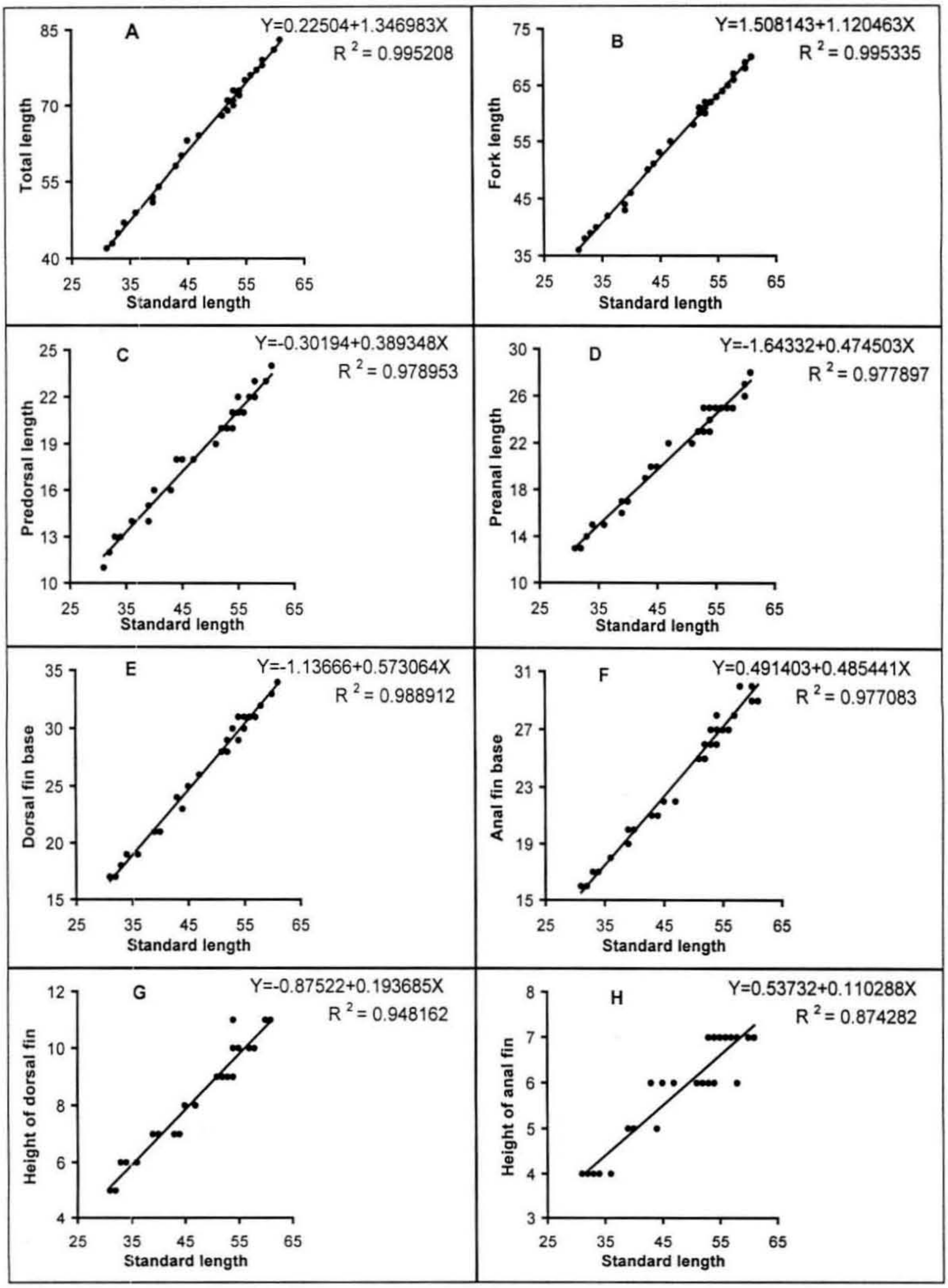



Figure 23

*S.ruconius:*

Regression of A) Total length on Standard length B) Fork length on Standard length.
C) Predorsal length on Standard length D) Preanal length on Standard length.
E) Dorsal fin base on Standard length F) Anal fin base on Standard length.
G) Height of dorsal fin on Standard length H) Height of anal fin on Standard length.

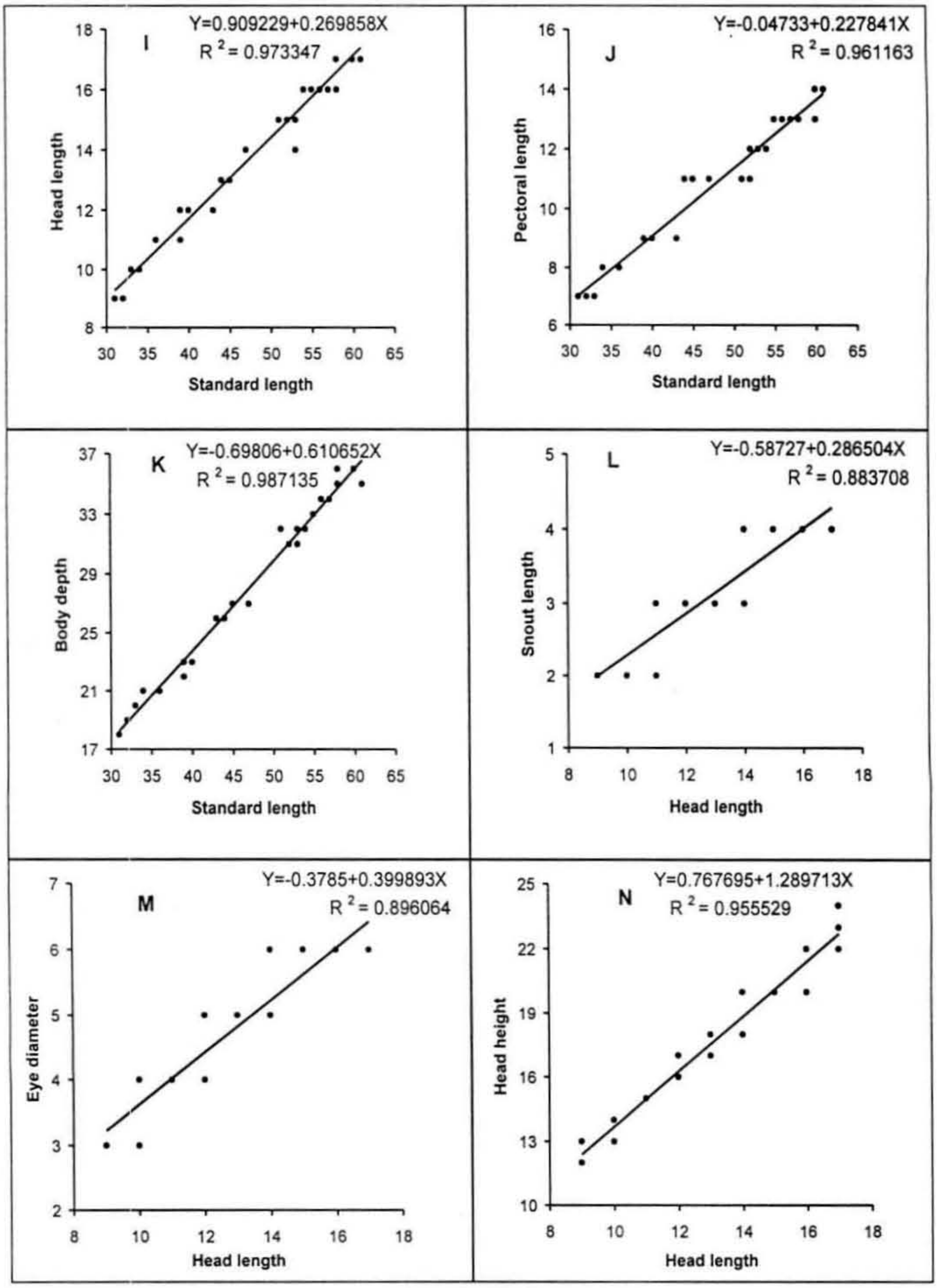



Figure 24

*S.ruconius:*

Regression of I) Head length on Standard length J) Pectoral length on Standard length.
K) Body depth on Standard length L) Snout length on Head length.
M) Eye diameter on Head length N) Head height on Head length.

## GENUS 3 *GAZZA* RUPPEL, 1835

(Type species *Gazza equulaeformis* Ruppel ,1835

= *Scomber minutus* Bloch , 1797)

### 15. *Gazza minuta* (Bloch, 1797)

(Plate II, Fig. 7; Figures 25-26; Tables 1-3)

*Scomber minutus* Bloch, 1797, *Systema Ichthylogiae*, p. 110, tab. 429, fig. 2.

DESCRIPTION

D.VIII, 15-16; P. ii, 13-14, i-ii; V. I , 5 ; A. III , 13-14 ; C. 15 ; Ll.57-59.

*As percent of standard length*: Total length 129.89-134.72 (131.59); fork length 113.24-117.81 (115.20); predorsal 38.71-42.86 (40.32); preanal 49.25-54.95 (51.63); dorsal base 51.28-54.84 (53.22); anal base 39.08-44.44 (41.86); head 30.30-34.07 (31.87); dorsal height 15.15-20.83 (17.81); anal height 13.64-16.44 (15.05); pectoral 15.79-19.48 (17.55); depth 38.71-45.05 (42.00).

*As percent of head length*: Snout 23.81-29.17 (26.36); eye 33.33-40 (36.52); head height 84-100 (91.68).

Body oval, compressed and moderately deep. Dorsal and ventral profiles equally convex. Snout pointed. Mouth large, lips thick and broad. Mouth when protracted forms a horizontal tube. Gape of mouth oblique and near the middle of eye. Mandible at an angle of about 45° with the horizontal. A single series of small sharp teeth on the upper jaw, with a big and curved canine tooth on each side of the symphysis. In the lower jaw a series of curved pointed teeth are present, becoming larger anteriorly, with a pair of symphysial canines, with a notch between them to receive the upper canines. Pre-operculum with an obtuse angle, its lower margin finely serrated. Two small spines on top of the head immediately above the eye and opposite its front margin. Lateral line convex from the origin and is parallel to the dorsal profile extending posteriorly, but getting obsolete near to the end of the soft dorsal fin. Ventrals with axillary scales. Tip of the ventrals not reaching the origin of anals. Caudal deeply forked.

COLOUR: Silvery, back greyish, upper half of the body with greyish, irregular marks, or vertical wavy lines or faint irregular blotches, extending to below lateral line. Membrane of spinous dorsal, black at the edge. Snout margin dotted black. Inner side of pectoral base with black dots. About seven grey irregular blotches along the lateral line. Front part of anal fin yellowish. Edge of the gill opening on the lower side, covered by the opercular flap also dotted black. A black narrow line along the base of the dorsal fin. Posterior edges of the caudal fin dusky. Black minute dots all over the ventral half of the body.

DISTRIBUTION: Though it does not form a fishery by itself or dominate the catch at any particular locality, it contributes substantially to the silverbelly catch along both coasts of the country. It is distributed off Cochin, Cape Comorin, Quilon, Tuticorin, Pamban, Mandapam, Madras, Porto Novo, Visakhapatnam and Kakinada and especially abundant at Tuticorin, Pamban and Mandapam.

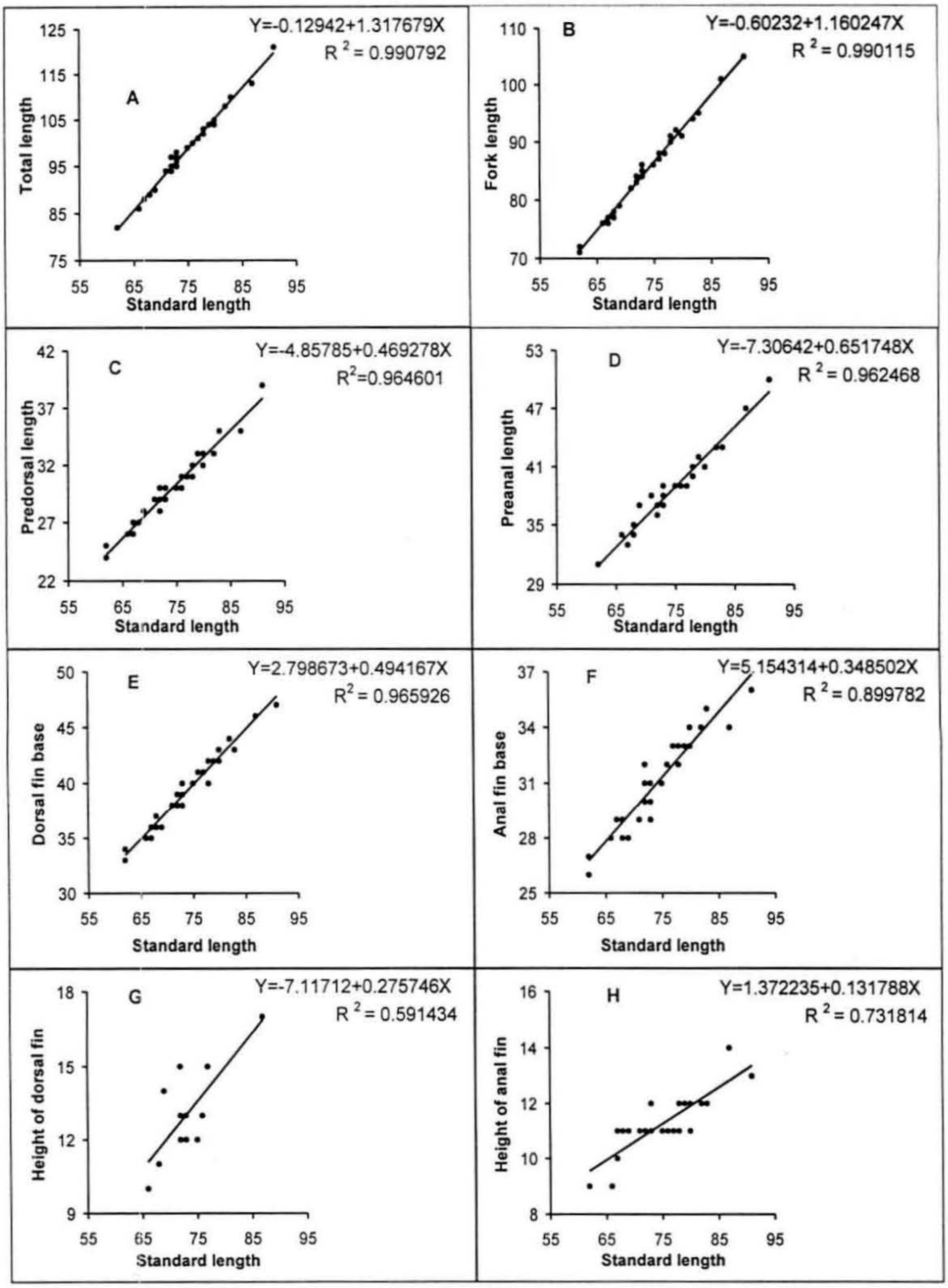



Figure 25

*G.minuta:*

Regression of A) Total length on Standard length B) Fork length on Standard length.
C) Predorsal length on Standard length D) Preanal length on Standard length.
E) Dorsal fin base on Standard length F) Anal fin base on Standard length.
G) Height of dorsal fin on Standard length H) Height of anal fin on Standard length.

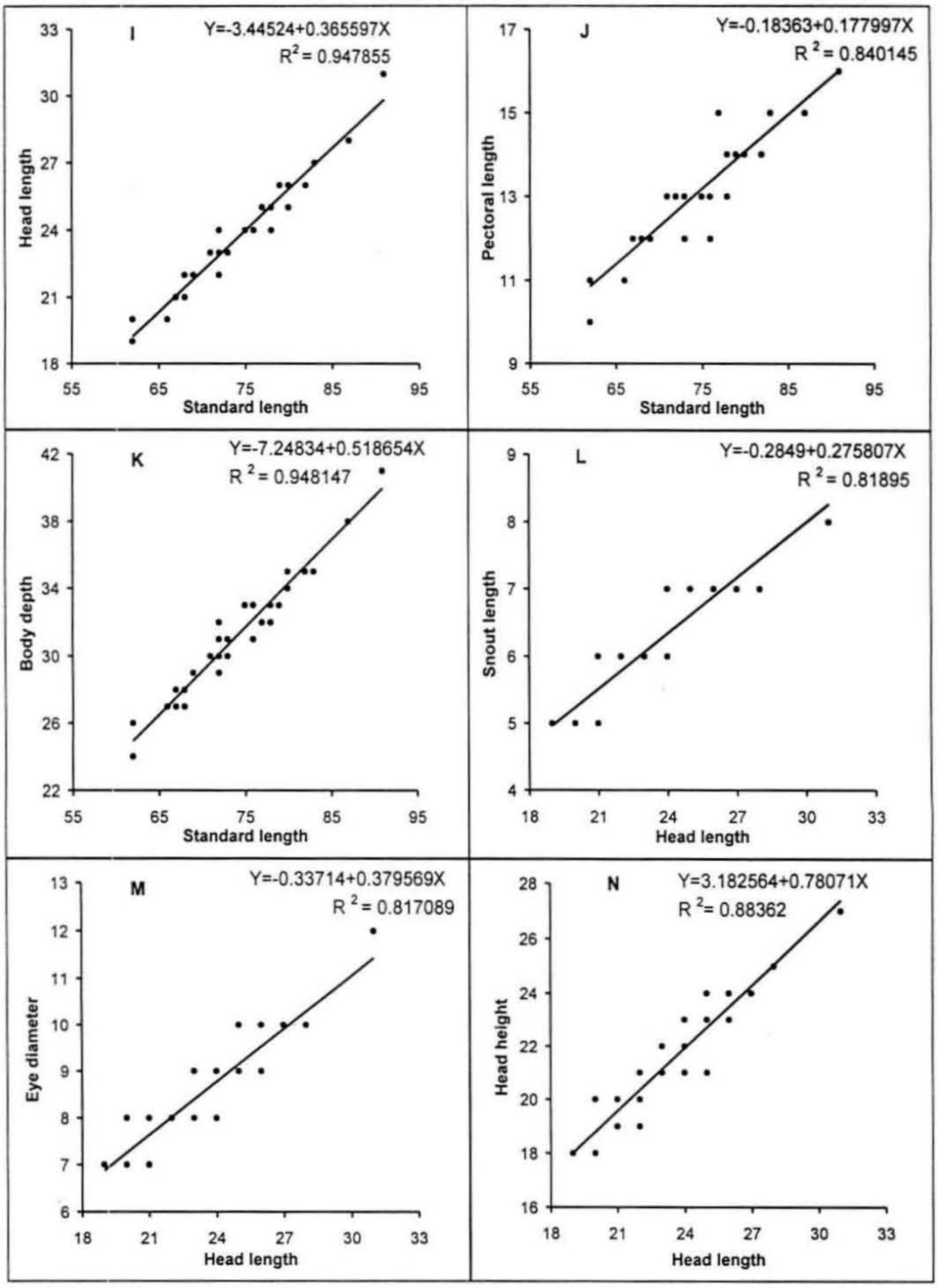



Figure 26

*G.minuta:*

Regression of I) Head length on Standard length J) Pectoral length on Standard length.
K) Body depth on Standard length L) Snout length on Head length.
M) Eye diameter on Head length N) Head height on Head length.

## 16. *Gazza achlamys* Jordan and Starks , 1917

(Plate II, Fig. 8; Table 1-2)

*Gazza achlamys* Jordan & Starks, 1917, *Ann. Car. Mus.,* 11: 446, pl.45.

DESCRIPTION

D.VIII, 16; P. ii, 13, ii; V. I, 5; A. III, 14; C. 15. Ll. 59-61.

*As percent of standard length*: Total length 129.55-134.18 (131.70); fork length 115.12-120.25 (117.09); predorsal 39.77-41.98 (40.64); preanal 50.62-52.33 (51.30); dorsal base 51.16-54.43 (52.33); anal base 39.77-44.30 (41.91); head 31.82-34.18; dorsal height 20.78; anal height 17.05-20.93 (19.18); pectoral 18.18-19.77 (18.73); depth 46.59-49.37 (47.71).

*As percent of head length:* Snout 24.00-28.57 (25.88); eye 35.71-39.29 (37.01); head height 95.59-100.00 (94.89).

Body oval, somewhat compressed and deep. Dorsal and ventral profiles equally convex. The dorsal profile shows a slight concavity over the front border of the eye. Snout pointed. Mouth large, lips broad and thick. Mouth when protracted forms a horizontal tube. Gape of mouth oblique and opposite the middle of the eye. Mandibles almost straight, ascending with an angle of about 50-60$^{\circ}$ . A band of small villiform teeth on each side and a pair of symphysial canines on the upper jaw, lower jaw having a series of teeth on the sides, getting bigger when going forward, with a pair of large canine teeth at the symphysis, with a gap between them to receive the upper canines. Two small supraorbital spines present opposite the front border of eye. Pre-operculum with its lower margin finely serrated. Lateral line convex from the origin and runs parallel to the dorsal profile extending posteriorly up to the base of the caudal fin. Ventrals with axillary scales and tip of the ventrals does not reach the origin of the anals. Caudal deeply forked.

COLOUR: Body silvery, back greyish, with dark irregular marks or circles, extending to little beyond lateral line, which often disappear on preservation. Membrane of the spinous dorsal black in its distal portion. Snout tip dotted grey. Edge of soft dorsal also grey. Inner side of the pectoral fin dotted black and dark pigment spots present along the edge of the ventral half of the gill opening, covered by the opercular flap. Caudal dusky at its posterior margin. Minute black dots all over the ventral half of the body.

DISTRIBUTION: Very rare in Indian waters with only stray specimens reported. It is reported from the Great Nicobar island (Rani Singh and Talwar 1978b) and known to occur off southern India. It is reported from off Cochin for the first time in the present study.

Table 1: Frequency distribution of pectoral fin rays in the silverbellies collected off Kerala coast

| Species | Pectoral fin rays (Branched + Unbranched) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 15 | 16 | 17 | 18 | 19 | 20 | 21 | N | $\bar{X}$ | SD | SE |
| *L.splendens* | - | - | 29 | 1 | - | - | - | 30 | 17.03 | ± 0.18 | ± 0.03 |
| *L.brevirostris* | - | - | 1 | 24 | 5 | - | - | 30 | 18.13 | ± 0.43 | ± 0.08 |
| *L.bindus* | 9 | 19 | 2 | - | - | - | - | 30 | 15.77 | ± 0.57 | ± 0.10 |
| *L.equulus* | - | - | - | - | 5 | 20 | 5 | 30 | 20 | ± 0.59 | ± 0.11 |
| *L.dussumieri* | - | - | - | 13 | 16 | 1 | - | 30 | 17.97 | ± 3.24 | ± 0.59 |
| *L.daura* | - | - | - | 1 | 8 | 1 | - | 10 | 19 | ± 0.47 | ± 0.15 |
| *L.blochi* | - | - | 23 | 7 | - | - | - | 30 | 17.23 | ± 0.43 | ± 0.08 |
| *L.lineolatus* | - | 10 | - | - | - | - | - | 10 | 16 | - | - |
| *L.leuciscus* | - | - | - | 9 | 1 | - | - | 10 | 18.1 | ± 0.32 | ± 0.10 |
| *L.fasciatus* | - | - . | - | 1 | 1 | 1 | - | 3 | 19 | ± 1 | ± 0.58 |
| *L.smithursti* | - | - | - | - | - | - | 1 | 1 | - | - | - |
| *L.elongatus* | - | 2 | - | - | - | - | - | 2 | 14 | - | - |
| *S.insidiator* | - | - | 14 | 16 | - | - | - | 30 | 17.53 | ± 0.51 | ± 0.09 |
| *S.ruconius* | - | - | 11 | 19 | - | - | - | 30 | 17.63 | ± 0.49 | ± 0.09 |
| *G.minuta* | - | 1 | 20 | 9 | - | - | - | 30 | 17.27 | ± 0.52 | ± 0.10 |
| *G.achlamys* | - | - | 5 | - | - | - | - | 5 | 17 | - | - |

Table: 2 Frequency distribution of Dorsal Fin Spines, Dorsal Fin Rays , Anal Fin Rays and Caudal Fin Rays in the silverbellies collected off Kerala coast

| Species | Dorsal fin spines | | | | | | Dorsal fin rays | | | | | | | Anal fin rays | | | | | | | Caudal fin rays | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 8 | 9 | N | $\bar{X}$ | SD | SE | 15 | 16 | 17 | N | $\bar{X}$ | SD | SE | 13 | 14 | 15 | N | $\bar{X}$ | SD | SE | 14 | 15 | 16 | N | $\bar{X}$ | SD | SE |
| *L. splendens* | 29 | 1 | 30 | 8.03 | 0.18 | 0.03 | - | 30 | - | 30 | 16.00 | - | - | - | 29 | 1 | 30 | 14.03 | 0.18 | 0.03 | - | 28 | 2 | 30 | 15.07 | 0.25 | 0.046 |
| *L. brevirostris* | 30 | - | 30 | 8.00 | - | - | - | 29 | 1 | 30 | 16.03 | 0.18 | 0.03 | - | 30 | - | 30 | 14.00 | - | - | - | 30 | - | 30 | 15.00 | - | - |
| *L. bindus* | 30 | - | 30 | 8.00 | - | - | - | 29 | 1 | 30 | 16.03 | 0.18 | 0.03 | - | 29 | 1 | 30 | 14.03 | 0.18 | 0.03 | 1 | 29 | - | 30 | 14.97 | 18 | 3.286 |
| *L. equulus* | 30 | - | 30 | 8.00 | - | - | 1 | 27 | 2 | 30 | 16.03 | 0.32 | 0.06 | 2 | 28 | - | 30 | 13.93 | 0.25 | 0.05 | - | 30 | - | 30 | 15.00 | - | - |
| *L. dussumieri* | 30 | - | 30 | 8.00 | - | - | - | 30 | - | 30 | 16.00 | - | - | - | 30 | - | 30 | 14.00 | - | - | - | 30 | - | 30 | 15.00 | - | - |
| *L. daura* | 10 | - | 10 | 8.00 | - | - | - | 10 | - | 10 | 16.00 | - | - | - | 10 | - | 10 | 14.00 | - | - | - | 10 | - | 10 | 15.00 | - | - |
| *L. blochi* | 30 | - | 30 | 8.00 | - | - | 1 | 29 | - | 30 | 15.97 | 0.18 | 0.03 | - | 30 | - | 30 | 14.00 | - | - | - | 30 | - | 30 | 15.00 | - | - |
| *L. lineolatus* | 10 | - | 10 | 8.00 | - | - | - | 10 | - | 10 | 16.00 | - | - | - | 10 | - | 10 | 14.00 | - | - | - | 10 | - | 10 | 15.00 | - | - |
| *L. leuciscus* | 10 | - | 10 | 8.00 | - | - | - | 10 | - | 10 | 16.00 | - | - | - | 10 | - | 10 | 14.00 | - | - | - | 10 | - | 10 | 15.00 | - | - |
| *L. fasciatus* | 3 | - | 3 | 8.00 | - | - | - | 3 | - | 3 | 16.00 | - | - | - | 3 | - | 3 | 14.00 | - | - | - | 3 | - | 3 | 15.00 | - | - |
| *L. smithursti* | 1 | - | 1 | 8.00 | - | - | - | 1 | - | 1 | 16.00 | - | - | - | 1 | - | 1 | 14.00 | - | - | - | 1 | - | 1 | 15.00 | - | - |
| *L. elongatus* | 2 | - | 2 | 8.00 | - | - | - | 2 | - | 2 | 16.00 | - | - | - | 2 | - | 2 | 14.00 | - | - | - | 2 | - | 2 | 15.00 | - | - |
| *S. insidiator* | 30 | - | 30 | 8.00 | - | - | - | 30 | - | 30 | 16.00 | - | - | - | 30 | - | 30 | 14.00 | - | - | - | 30 | - | 30 | 15.00 | - | - |
| *S. ruconius* | 30 | - | 30 | 8.00 | - | - | - | 30 | - | 30 | 16.00 | - | - | - | 30 | - | 30 | 14.00 | - | - | - | 30 | - | 30 | 15.00 | - | - |
| *G. minuta* | 30 | - | 30 | 8.00 | - | - | 2 | 28 | - | 30 | 15.93 | 0.25 | 0.05 | 1 | 29 | - | 30 | 13.97 | 0.18 | 0.03 | - | 30 | - | 30 | 15.00 | - | - |
| *G. achlamys* | 5 | - | 5 | 8.00 | - | - | - | 5 | - | 5 | 16.00 | - | - | - | 5 | - | 5 | 14.00 | - | - | - | 5 | - | 5 | 15.00 | - | - |

Table 3: Frequency distribution of lateral line scales in the silverbellies collected off Kerala coast.

| Species | Lateral Line Scales | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 64 | 66 | 67 | 69 | N | $\bar{X}$ | SD | SE |
| *L. splendens* | 1 | - | 2 | 4 | 2 | 1 | 5 | 4 | 4 | 4 | 1 | 1 | 1 | - | - | - | - | - | - | - | - | - | 30 | 51.27 | 2.9 | 0.529 |
| *L. brevirostris* | - | - | - | - | - | - | - | 1 | 1 | - | 3 | 2 | 6 | 2 | 5 | 3 | 4 | 2 | 1 | - | - | - | 30 | 58.23 | 2.76 | 0.504 |
| *L. equulus* | - | - | - | - | - | - | - | - | - | 2 | - | 4 | 5 | 7 | 3 | 4 | 2 | 2 | 1 | - | - | - | 30 | 58.33 | 2.31 | 0.422 |
| *L. dussumieri* | - | - | - | - | - | - | 1 | - | - | 1 | 4 | 6 | 8 | 3 | 5 | 2 | - | - | - | - | - | - | 30 | 56.87 | 1.925 | 0.351 |
| *L. daura* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 4 | 4 | 1 | 10 | 66.5 | 1.269 | 0.401 |
| *L. blochi* | | - | - | - | 1 | 1 | - | 1 | - | 1 | 2 | 10 | 14 | - | - | - | - | - | - | - | - | - | 30 | 55.77 | 2.029 | 0.37 |
| *L. leuciscus* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 5 | - | 5 | - | - | - | 10 | 62.5 | 1.581 | 0.5 |
| *L. fasciatus* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 | - | - | | - | 3 | 62 | - | - |
| *L. smithursti* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | 1 | 61 | - | - |
| *G. minuta* | - | - | - | - | - | - | - | - | - | - | - | - | 3 | 23 | 4 | - | - | - | - | - | - | - | 30 | 58.03 | 0.49 | 0.089 |

## Plate 1

1. *Leiognathus splendens* (Cuvier, 1829)

2. *Leiognathus brevirostris* (Valenciennes, 1835)

3. *Leiognathus bindus* (Valenciennes, 1835)

4. *Leiognathus equulus* (Forsskal, 1775)

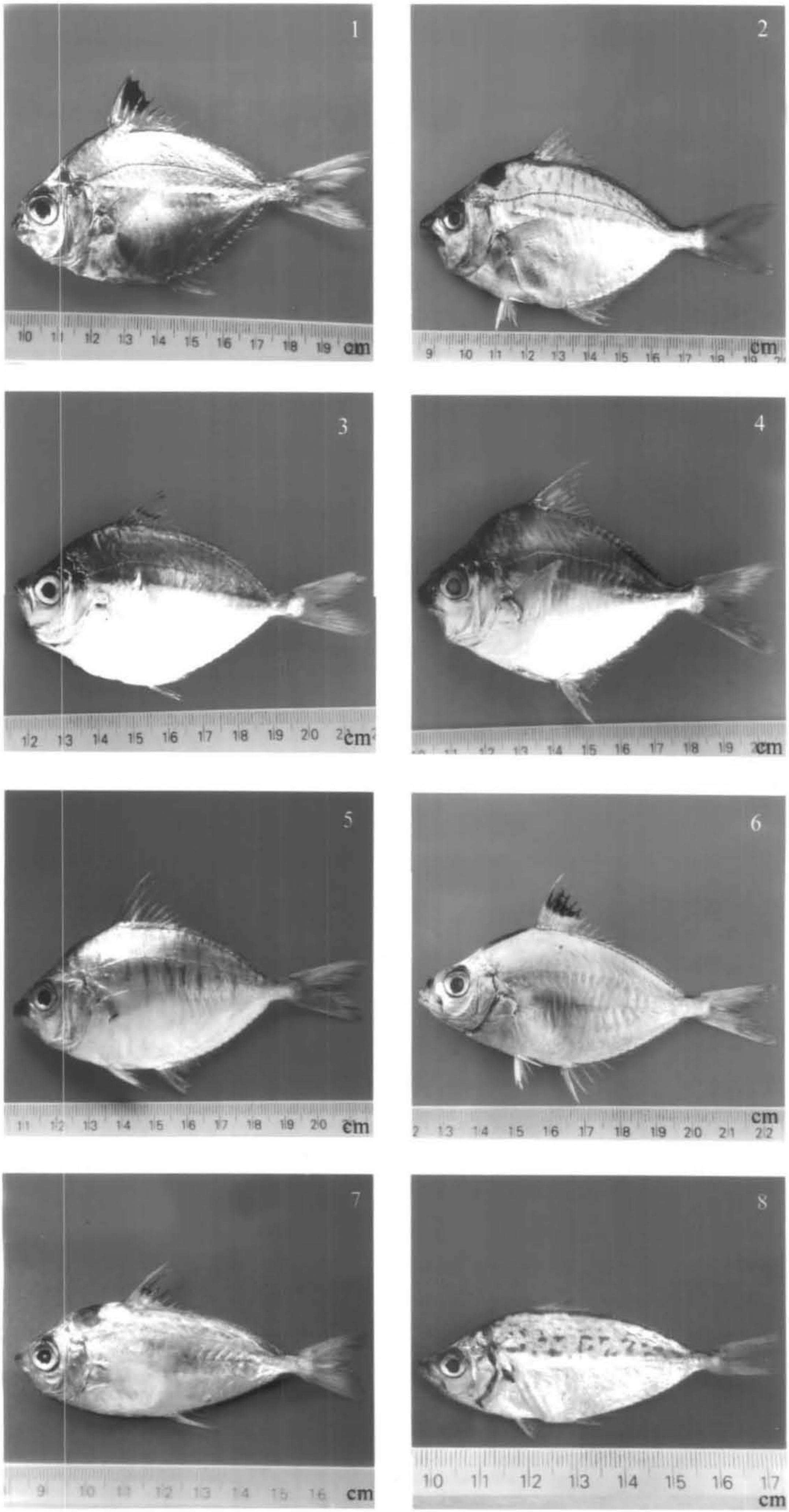
5. *Leiognathus dussumieri* (Valenciennes, 1835)

6. *Leiognathus daura* (Cuvier, 1829)

7. *Leiognathus blochi* (Valenciennes, 1835)

8. *Leiognathus lineolatus* (Valenciennes, 1835)

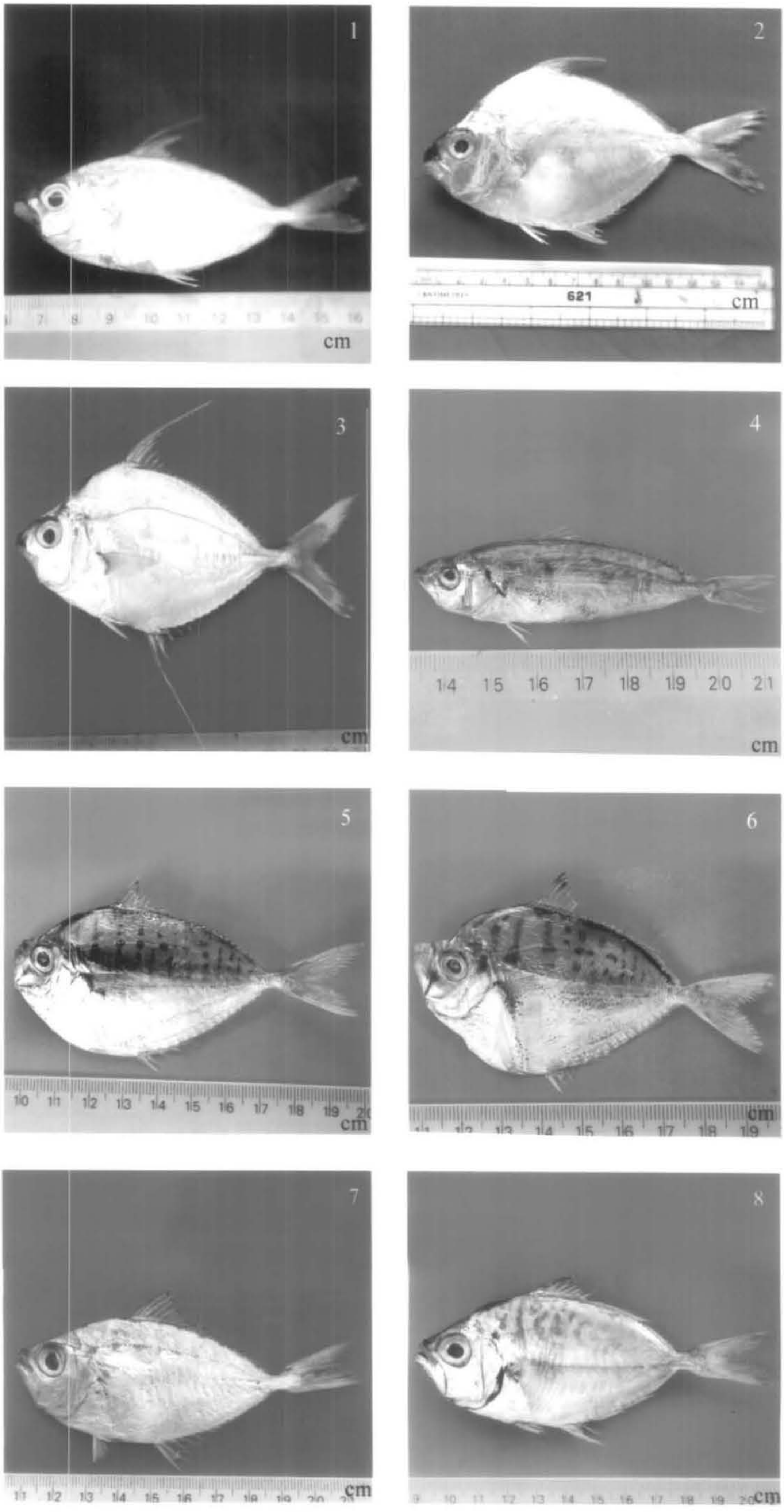
# Plate 1



## Plate 2

1. *Leiognathus leuciscus* (Gunther, 1860)
2. *Leiognathus fasciatus* (Lacepede, 1803)
3. *Leiognathus smithursti* (Ramsay and Ogilby, 1886)
4. *Leiognathus elongatus* Gunther, 1874
5. *Secutor insidiator* (Bloch, 1787)
6. *Secutor ruconius* (Hamilton-Buchanan, 1822)
7. *Gazza minuta* (Bloch, 1797)
8. *Gazza achlamys* Jordan and Starks, 1917

Plate 2



# Chapter II

# Maturation, Spawning and Fecundity

# MATURATION, SPAWNING AND FECUNDITY

## INTRODUCTION

Reproduction is an important event in the life of an organism in perpetuating its population. Reproduction and growth contribute to the increase in the biomass of the population. Determination of the timing of spawning and the total output of eggs is necessary for assessing the reproductive potential of a population. These studies along with information on the survival of early and vulnerable stages in the life history would facilitate determination of the short term and long term fluctuations in the production of year classes and their recruitment to the fishery as exploitable stocks. Thus, the success or failure of spawning in any one year in a population, affects the fishery. Hence studies on maturation, spawning and fecundity become essential in formulating management strategies of exploited fish stocks. Besides, interannual variations in spawning period (or peak spawning period) and recruitment are known to occur due to several reasons but mainly pertaining to those of the environment and the size of the spawning stock. Continuous monitoring of the maturation and spawning of an exploited fish stock, therefore, is also essential. The peculiarities of reproduction in a species are adaptations for preservation of species and its abundance (Nikolsky, 1963). The size and quality of the replenishment of the population are determined by the quality and abundance of the spawning population and also by the environmental conditions under which the eggs and larvae have to survive and grow.

The process of spawning is influenced by certain internal factors and external stimuli. The internal factors inducing maturation and spawning are the hormones. The external factors influencing maturation and spawning are varied. In temperate waters, the existence of favourable temperature was considered important in spawning. In tropical waters where variations in sea water temperature and food supply are not so well marked, such factors may not act as trigger stimuli (Bensam, 1999). However changes in salinity and temperature, associated with monsoon rains in certain regions, may act as stimuli for spawning (Murty and Edelman, 1968, Qasim 1973a). Usually in marine fishes, the spawning process is accompanied by shoaling of the species in large numbers, when contents of the male and female gonads are released to the exterior where fertilization occurs. Often, the spawning of one individual induces the others to follow and the presence of sperms in water is known to induce the females to shed their eggs.

Among the important studies on the maturation and spawning of fishes, the works of Clark (1925,1934), Wood (1930), Hickling and Rutenberg (1936), De Jong (1940), Kesteven (1947), Fairbridge (1951), Le Cren (1951), June (1953), Bunag (1956), Yamamoto and Yamazaki (1961), Bowers and Holliday (1961), Pollard (1972), Hislop and Hall (1974), Holden and Raitt (1974), Foucher and Beamish (1977), De Martini and Fountain (1981), Wallace and Selman (1981), De Vlaming *et al.* (1982), Forberg (1983), Hunter and Macewicz (1985), Hunter *et al.* (1985), Cayre and Laloe (1986), Mayer *et al.* (1988) and Bolger and Connolly (1989) deserve special mention as they principally deal with the methodologies. Some important contributions to the understanding of the maturation and spawning of fishes from India include those of Prabhu (1956), Pradhan and Palekar (1956), Qasim and Qayyum (1961), Annigeri (1963), Rao (1963), Raju (1964), Antony Raja (1967,1971), Qasim (1973a), Devaraj (1977) and James and Baragi (1980).

In silverbellies, several studies were made on maturation and spawning from off the east coast of India. Arora (1952) studied the length at maturity and spawning period of *Leiognathus splendens* from Rameswaram Island off the coast of Tamilnadu. Balan (1963) studied the biology of *L. bindus* off the Calicut coast. Rao (1967a) gave an account of the lipid levels associated with the reproductive cycles in *L. splendens* from off Madras. Mahadevan Pillai (1972) studied the spawning habits and fecundity of four species of silverbellies from Tuticorin. James (1986) and James and Badrudeen (1975, 1981, 1986) studied the spawning of some silverbelly species from the Palk Bay and Gulf of Mannar. Murty (1983, 1990) studied the maturation and spawning in *L. bindus* and *Secutor insidiator* from Kakinada. Jayabalan (1986) and Jayabalan and Ramamoorthi (1986) studied the spawning biology of *L. splendens* and *S. insidiator* from Porto Novo.

It is clear from the above that except for the work of Balan (1963), there has been no study on the spawning biology of silverbelly species from off Kerala. Even this work is restricted to only one species, *L. bindus* from the nearshore waters. The present study was undertaken to fill the gaps in the knowledge on maturation and spawning in *L. splendens* and *S. insidiator* from the west coast of India in general and Kerala coast in particular.

## MATERIALS AND METHODS

The study is based on 2112 specimens of *L. splendens* (length range 34 mm to 115 mm) and 1546 specimens of *S. insidiator* (length range 47 mm to 111 mm) collected during October 1998 - December 1999 from Cochin Fisheries harbour and Neendakara Fisheries harbour. The specimens were collected at fortnightly intervals from these two sampling centres. After measuring the length and weight of each specimen, the belly was cut open to note the sex, colour and general appearance of the gonads, which were then carefully removed and preserved in 5% formalin, in labelled bottles.

Since spawning is synchronous in the population, the studies on the maturation and spawning were carried out on the basis of the ovaries only, although development of male gonads was also followed.

i. *Quantification of ovaries into different stages of maturation*: The appearance of the ovaries in fresh condition, the proportion of the area occupied by them in the body cavity and the structure and diameter range of the intraovarian ova were considered for quantification of ovaries into different stages of maturation. Though there are some earlier studies on this aspect in the species studied here from India, an independent scale of maturation stages was developed in the present study in view of the inadequacies of the earlier studies. Five stages (I-V) of maturation have been recognised in the two species on the basis of the above criteria.

ii. *Ova diameter frequency distribution:* This study was conducted in *L. splendens* only. For measurement of ova diameters, transverse sections were taken from the anterior, middle and posterior regions of the ovary, the ova were teased out on micro slides taking utmost care to separate out all the ova in the samples. The observations on ova diameter were made under microscope, using an ocular micrometer, at a set magnification where, one micrometer division equals 0.01125 mm. The ova were measured from the different regions of the ovary to see whether differences in the distribution of ova in different regions of the ovary occur. It was observed that the ova diameter frequency distribution in different parts of the ovary was the same. Hence, samples were taken from the middle of the ovary in all further studies. The ova diameters were measured by placing the micrometer in a horizontal position across the field of microscope and then reading the diameter of the egg in the same plane, irrespective of the shape of the ova, following Clark (1925). As the ova, due to distortion in preservation are almost never spherical in shape, this method gives measurements of the longest diameters of some eggs, of the shortest of others, or measurements between these two (De Jong, 1940). This method was successfully employed by later workers like De Jong (1940), June (1953), Yuen (1955) and by several Indian workers: Prabhu (1956), Radhakrishnan (1957), Sarojini (1957), Dharmamba (1959), Jhingran (1961), Varghese (1961), Raju (1964), Rao (1967b), Antony Raja (1967), Deshmukh (1973), Murty (1975, 1979, 1980, 1981), Vasudevappa and James (1980), Luther (1986), and many others. Different workers on silverbellies (James and Badrudeen, 1975, 1981, 1986; Murty, 1983; James, 1986 and Jayabalan, 1986) also employed the same method.

To avoid measuring each ovum more than once, the ova were arranged in rows on the slide and the diameters of ova in each row were measured by moving the slide along one direction. In the immature ovaries in which the ova were minute and it is not possible to arrange them in rows; they were spread evenly on the slide and the diameters of the ova lying parallel to two horizontal guidelines on the slide were measured. In mature ovaries, samples for diameter measurements were taken after noting the total weight of the ovary and the sample weight. All the ova in each sample spread on the slide were measured without any selection. The ova diameters were grouped into three micrometer division (md) class intervals (i.e., 1-3, 4-6, 7-9 etc.) to determine the frequency distribution of ova in the ovary. About 800 - 1000 ova were measured from each ovary.

iii. *Determination of length at first maturity*: For determining the length at first maturity ($L_{50}$), specimens with ovaries in stages IV and V of maturation were considered as mature and the proportion of such mature fish in each length group determined. The length at which about 50% of the fish are mature, has been taken as the $L_{50}$. As almost all the adult fish during the spawning season (or at least peak spawning season) are expected to be in mature stage, it is desirable to consider representative samples collected during this period for this purpose to eliminate the possibility of growth in length influencing the estimate of the length at first maturity. An attempt has been made in this direction in the present study.

iv. *Spawning :* The periodicity of spawning has been determined using the ova diameter frequency distribution in mature ovaries following Hickling and Rutenberg (1936) and De Jong (1940).

The distribution of sexes and maturation stages in fishes of different length groups in the samples was weighted to obtain the distribution in the total catch of the species in each month at Cochin and Neendakara Fisheries harbours. The estimates thus obtained from these centres were pooled. The spawning period was determined using the data on maturation stages in different months and the months of occurrence of gravid fishes has been taken as the spawning period. For this purpose only fishes of and above the length at first maturity ($L_{50}$) were considered as this would help in determining the peak spawning period more satisfactorily. The gonado-somatic index has also been studied for the purpose.

v. *Fecundity* : This study was done in *L. splendens* only. Estimation of fecundity is based on the mature ovaries (penultimate stage of ripeness) as all the ova destined to be spawned during the ensuing season are mature in such ovaries (Bagenal, 1968). The estimated number of mature ova in such ovaries represents the fecundity. Ripe ovaries were not considered for estimation of fecundity since there is a possibility of some of the ripe, hydrated eggs being lost from the ovary, before it can be taken for fecundity estimation. After removal of the external formalin, the weights of the ovaries were taken to the nearest 0.001 g in a 'Sartorius monopan chemical balance.' A small piece cut out from the middle of the ovary was also similarly weighed and transferred to a labelled bottle containing 5% formalin; the bottle was shaken to free the ova from the ovarian tissue; ova still attached to the ovarian tissue were released on a slide, with fine needles. After separating all the ova from the ovarian tissue, they were transferred to a counting chamber (divided into 100 small squares by transverse and longitudinal lines) and all the mature ova having a fully yolked structure, were counted under the microscope. Using the number of mature ova in the sample, the fecundity was estimated as:

**(Total weight of ovary/weight of the sample) X Number of mature ova in the sample**

## OBSERVATIONS AND RESULTS

### A. MATURATION

Maturation refers to the cyclic morphological changes that the male and female gonads undergo to attain full growth and ripeness (Qasim, 1973a). To understand these changes, it is necessary to follow the regular and cyclic changes undergone by the gonad. This can be best done by recognising the different phases in the cycle by assigning a set of unique stages that identify the state of maturity of the gonads, as they pass through the different stages of development and spawn. Thus, different maturity stages are assigned to the gonads, based on the well-defined criteria. The main objectives of the assessment of the stage of gonad development of individual fishes or determining the cycle of maturation and depletion of the gonads are:

1. to follow the gonadal development over time
2. to determine the spawning season
3. to determine the length at first maturity.
4. To estimate the spawning stock biomass.

There are different methods of studying the maturation (Qasim, 1973a; West, 1990).

*Histology*: Gonadal stages are determined from sections of the ovary taken. It is the most detailed but time consuming method.

*Measurement of oocyte size*: The maturity stage is assigned based on the largest and most advanced group of oocytes in the ovary

*Appearance of whole oocytes:* Staging is done based on the microscopic examination of whole oocytes and classifying them on the basis of their appearance (eg:-Unyolked transparent oocytes, yolked opaque oocytes and transluscent ripe oocytes).

*Gonadal index*: The seasonal change in the weight of the gonad during a year measured as the ratio of gonad weight and body weight particularly in females is known to be indicative of the development stage of the gonad, which helps in determining the spawning period.

*Condition factor or Ponderal index* : Seasonal changes in the condition factor provide information on the developmental stage of gonad for, the changes in the condition factor, among others are known to be associated with the rise and fall in gonad weight. However, since the body weight of the fish is influenced by a host of other factors, reliability of this method as an index of developmental stage of gonad and spawning period is limited, especially in tropical fishes, which are continuous spawners and do not exhibit drastic changes in gonad weight.

*Classification of gonads based on external appearance*: For determination of the cycle of maturity of gonads, the most common method is to define the stages of sexual maturity and follow them at regular intervals in samples representative of the population. The criteria used for quantification of maturity are colour and size of the gonads in relation to the body cavity, and the appearance of oocytes within it, as seen by the naked eye, or at least without the use of a microscope. This is one of the simplest methods of assessing maturity in fishes, though it should be used in conjunction with information on intraovarian ova.

In the present study, the ovaries were classified on the basis of the external appearance of the fresh ovary, and the intraovarian ova diameter and structure.

**i. Description of ovaries and ova**

The ovaries of *L. splendens* and *S. insidiator* are rounded unpaired structures lying in the middle of the body cavity attached to its dorsal wall. The mature ovary is compact, more or less spherical and occupies the bulk of the body cavity. It is bright yellow in colour with ova of different sizes.

Four groups of ova are distinguished in ripe ovaries:

*Type I (Immature ova):* Irregular shape, a few larger ova spherical, translucent, yolkless, nucleus clearly visible; ova diameters ranging from 3 to 12 md.

*Type II (Maturing ova)*: More or less spherical in shape, almost opaque. Nucleus not visible, ova diameters range from 12 to 33 m.d.

*Type III (Mature ova)*: Spherical in shape; opaque due to deposition of yolk; a clear space present around the periphery, ova diameters range from 24 to 44 m.d. (please see plate III)

*Type IV (Ripe ova)*: Ova large and spherical, translucent, a large fat globule present; ova diameters above 39 m.d. ( plate 3. 2 )

**ii. Maturation stages**

The following maturation stages have been recognised:

*Stage I (Immature female):* Ovaries occupy $1/4^{th}$ of the body cavity, pale yellow and translucent in appearance. The ova diameter ranges from 2-9 m.d.

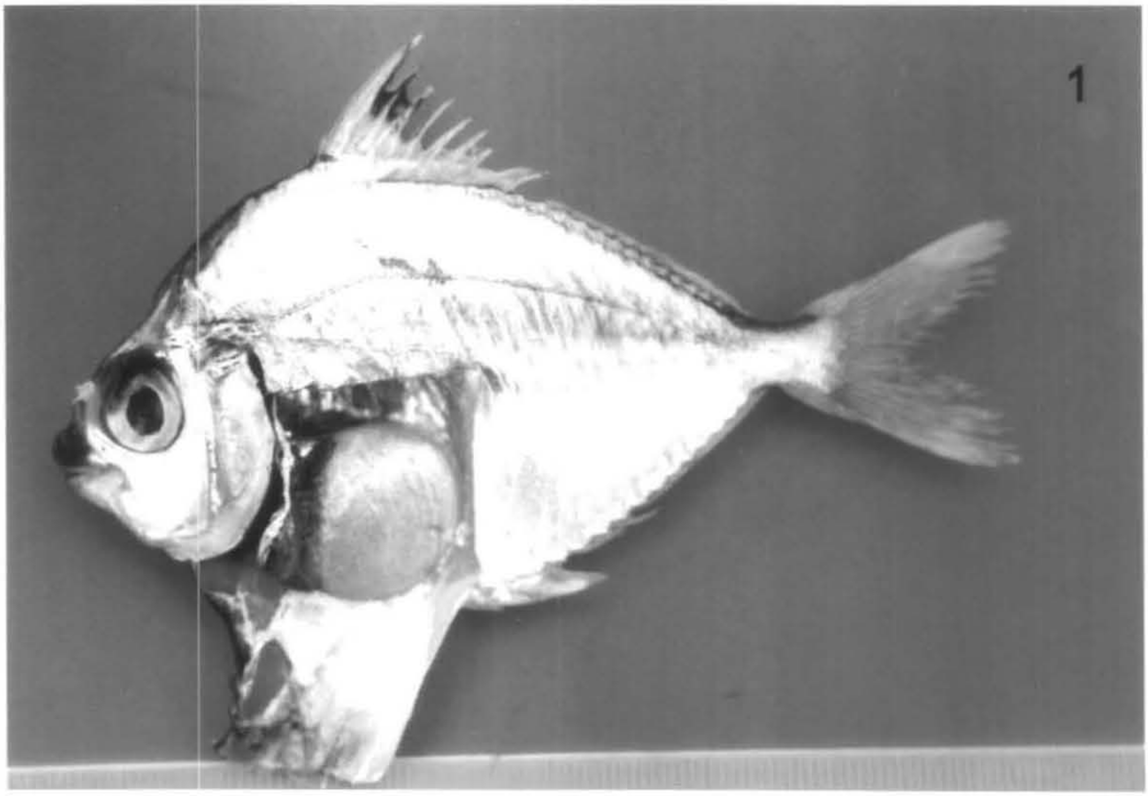
*Stage II (Immature female):* Ovaries occupy less than $1/3^{rd}$ of the body cavity. Pale yellow and translucent in appearance. Eggs could be slightly made out with the naked eye on teasing the ovary. Ova diameter ranges from 3-12 m.d. with a mode at 6 m.d.

*Stage III (Maturing female):* Ovary occupying 1/3 – 1/2 of the body cavity, eggs visible with the naked eye. Yellow in colour. Ova diameter ranges from 12-33 m.d. with the modal class at 27-30 m.d.

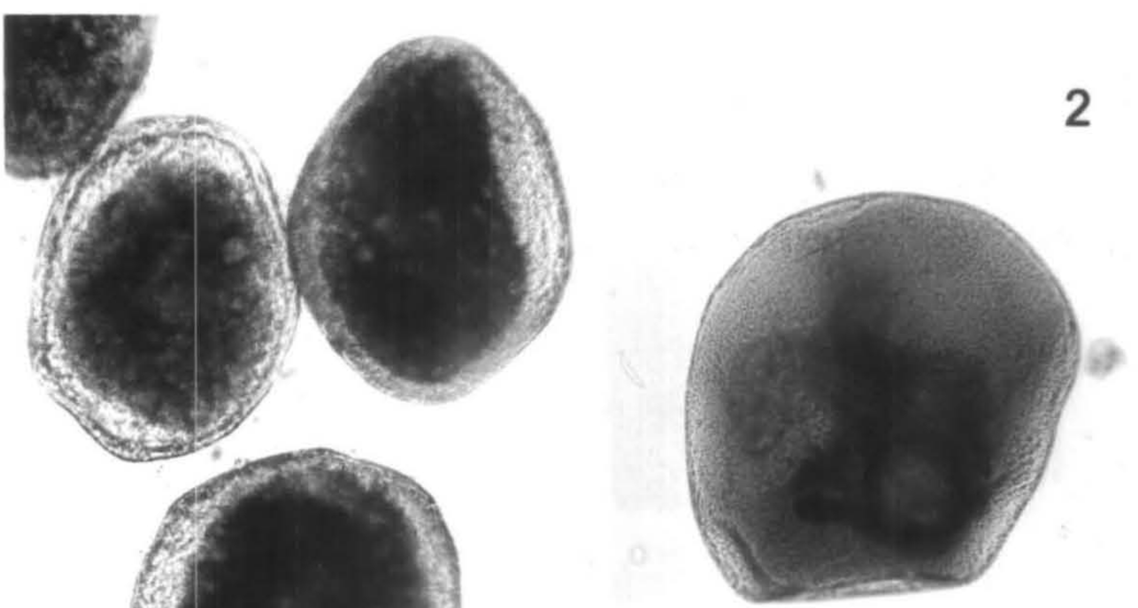
Plate 3

1. Adult specimen of *Leiognathus splendens* showing ripe ovary
2. Mature and ripe eggs of *Leiognathus splendens*

# Plate 3



1



2

*Stage IV (Mature female):* Ovaries occupying 1/3 – 3/4 of the body cavity. Yellow in colour. Eggs granular and clearly visible in the ovary. Ova diameter ranges from 24-45 m.d with the modal class at 33 m.d.

*Stage V (Ripe female):* Ovaries occupying 3/4 to nearly full body cavity. Bright yellow in colour (Plate 3 .1) Translucent eggs clearly visible in the ovary. Ova diameter ranges from 39 to 71 m.d with the modal class at 48-51 m.d.

Testes were classified as immature, mature and ripe on the basis of the colour and size.

**iii. Distribution of ova in the ovary**

Since different types of ova are present in the mature and ripe ovaries, it needs to be ascertained whether there is localisation of any particular type of ova in any region of the ovary or whether the ova are randomly distributed in the ovary. This was done by measuring 300 ova from the anterior, middle and posterior regions of the ovary separately, and measuring 300 ova pooled from the 3 regions of the ovary, from an adult Leiognathus *splendens* of 96 mm TL, and calculating the percentage frequency distribution of ova of different sizes in each of the samples. The data from the 3 regions of the ovary and the pooled data (Fig 27&28), show that the ova in the different stages of maturation are randomly distributed in the ovary and there is no evidence to suggest that the ova of any particular size are concentrated in any particular region of the ovary. Hence ova were taken only from the middle of the ovary throughout for measurements of ova diameters in each ovary.

**iv. Development of ova to maturity**

Ova diameter frequency profiles are used for studying the spawning habits of fishes on the basis of the assumption that the diameters of the eggs in ovaries well advanced towards spawning, give evidence of the duration of spawning in a fish. According to Hickling and Rutenberg (1936), where the spawning period is short and definite, the eggs to be spawned are sharply distinguishable from the general stock of transparent yolkless eggs, whereas when the spawning period is long and indefinite, the maturation of the eggs will be a continuous process and there will be no sharp separation between the

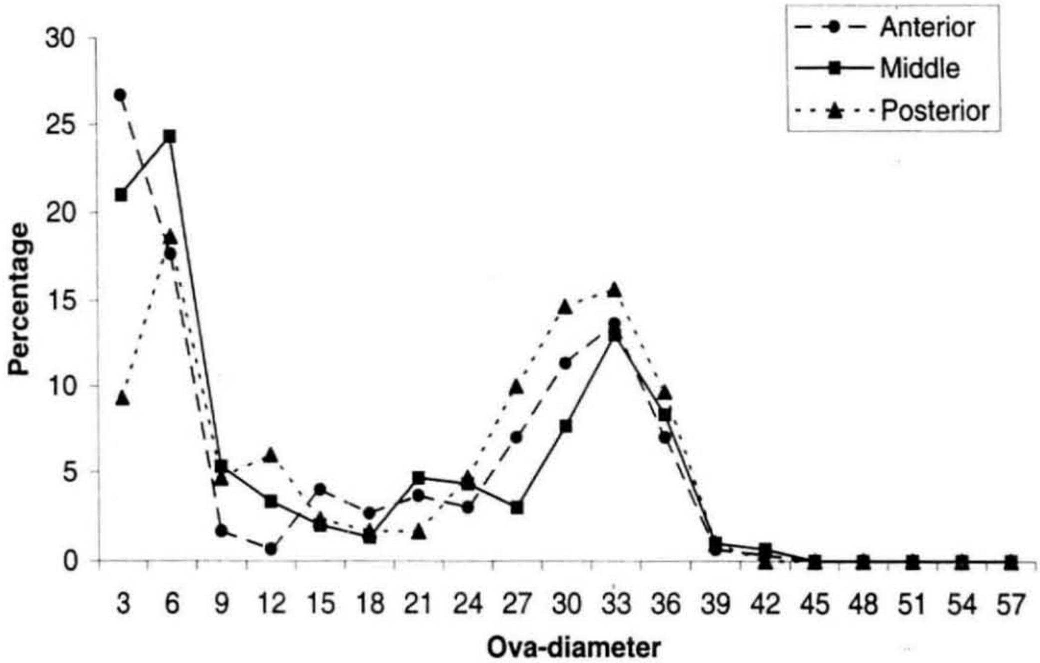



**Figure. 27 Ova diameter frequency distribution from the anterior, middle and posterior regions of the ovary**

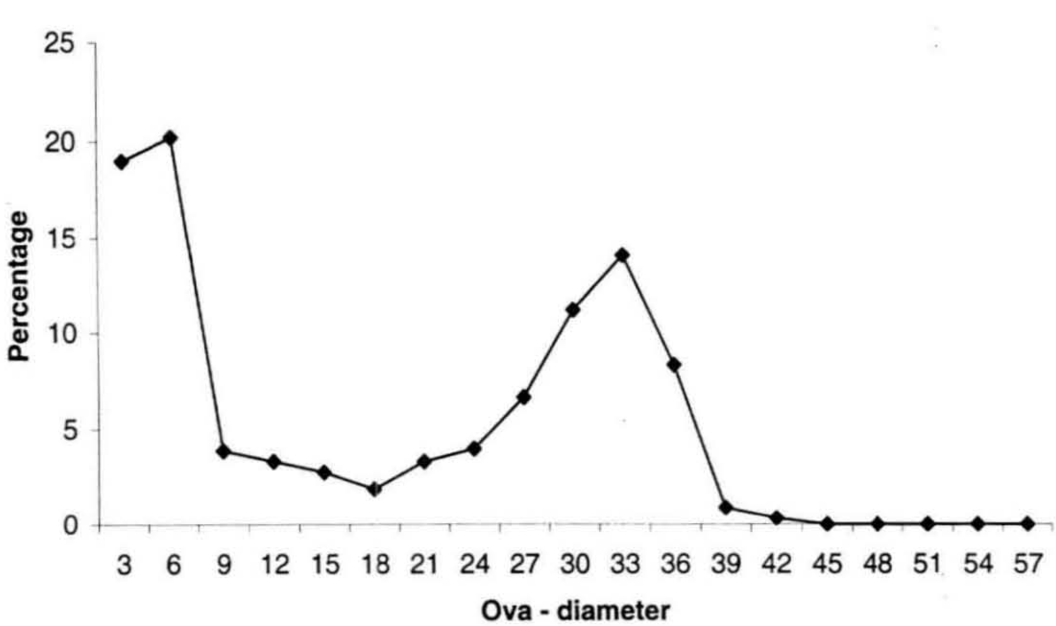



**Figure. 28 Pooled Ova diameter frequency distribution from the anterior, middle and posterior regions of the ovary**

general egg stock and the maturing eggs will pass continuously one into the other.

The study is based on 12 specimens of *L. splendens* ranging in length from 82 mm to 109 mm Total Length. (Fig 29) shows the progression in the ova diameter distribution from an immature stage I ovary through different stages, to a ripe stage V ovary. In an ovary beginning to undergo the maturation process, small, immature translucent ova are seen. The ova diameter ranges from 2 to 9 m.d, with the mode at 1-3 m.d. group. In stage II ovary, the maximum ova diameter is 14 m.d with the mode in the diameter distribution at 4-6 m.d. In this ovary, the immature stock present in the stage I ovary, with modal class at 1-3 m.d. is also present. In the stage III ovary, which characterises the maturing female, the largest group of the ova ranges from 15 to 36 m.d, with the mode at 27-30 m.d. Further development of the ova results in the modal class of the ova being shifted to 30-33 m.d., in the stage IV female, with the ova diameter ranging from 24 to 44 m.d. In the ripe female i.e., stage V, there is considerable increase in the size of the ova due to hydration and the diameter of the large ova ranges from 39 to 71 m.d (438 μ - 798 μ) with the modal class at 45-48 m.d. Another modal class is also seen in the ripe ovary with the ova size range of 15-39 m.d. and the mode at 24-27 m.d representing both maturing and mature oocytes. In all the ovaries of different stages examined, a batch of small eggs is consistently present with a modal class of 1-3 m.d. They represent the immature stock from which the eggs to be spawned are withdrawn.

The presence of two distinct modes, one of ripe ova and the other of maturing and mature ova in the ripe ovary of *L. splendens* suggests that immediately after releasing the batch of ripe ova, the ovary returns to the mature stage (stage IV). The fact that a group of mature ova follows the ripe group shows that another spawning takes place soon; naturally yet another group of mature ova will follow this, as the withdrawal of eggs is in batches, for undergoing maturation and that is a continuing process. James and Baragi (1980) made similar conclusions in their studies on the ova-diameter frequency distribution of three marine fishes.

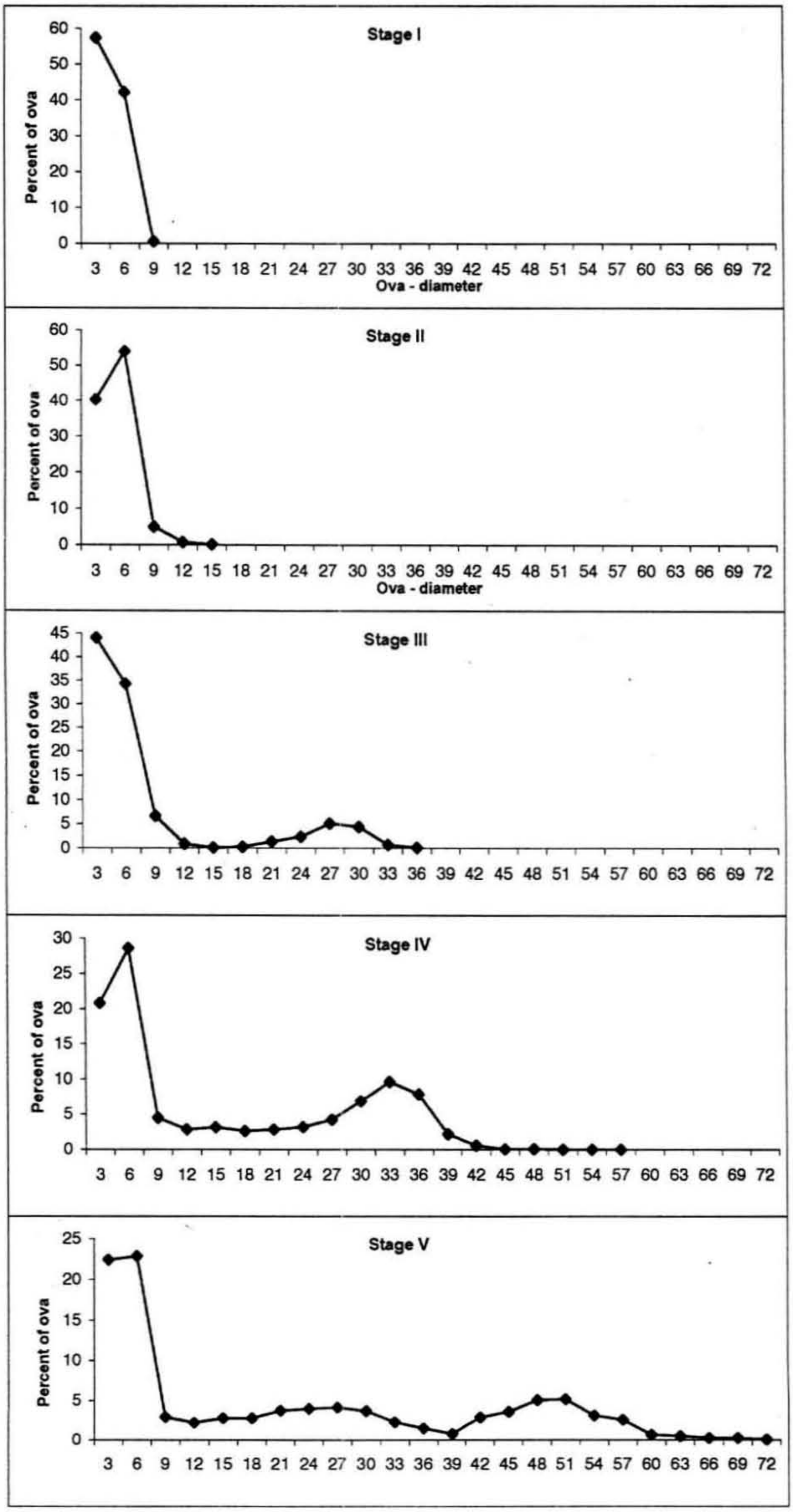



**Fig. 29 Ova diameter frequency distribution in the different stages of maturation in L.splendens**

### v. Length at first maturity

Length at first maturity in fishes is determined on the basis of the minimum length at which at least 50 % of the fish are mature during the spawning season. Knowledge of length at first maturity (and from this the age at first maturity) is useful in determining the spawning period and to estimate the spawning stock size.

In the present study the lengths of fishes were grouped into 5 mm class intervals and the percentage of mature fishes (stage IV and V) in each length group determined. In *Leiognathus splendens*, the data of October 98 to January 99 were considered on the basis of the abundance of mature fishes during these months in comparison to other months (Fig. 30). In *Secutor insidiator*, pooled data of September 99 - December 99 were considered for the purpose for the reason cited above (Fig. 32). The estimates were also made using all the data of 13 months (Figs. 31&33).

In *Leiognathus splendens,* the length at first maturity was estimated as 75 mm (beginning of the length range of 75-79mm) with the data of all 13 months and 70 mm by taking the data of four months. In *S. insidiator,* the estimated values are 80 and 75 mm respectively.

## B. SPAWNING

Knowledge of spawning habits and spawning periods is important for a variety of reasons, particularly to estimate the larval abundance and recruitment, to regulate fisheries by imposing closed seasons and/or closed areas, to facilitate understanding the growth and in conjunction with knowledge of recruitment, to forecast the yield

i. Occurrence of gravid fishes

Spawning period is determined on the basis of time series data on proportion of gonads in different stages of maturation, gonado-somatic index and availability of early life stages in the plankton. In the present study, this is done by following the first two approaches. The monthly distribution of gonads of different maturity stages during the period October 1998 to December 1999

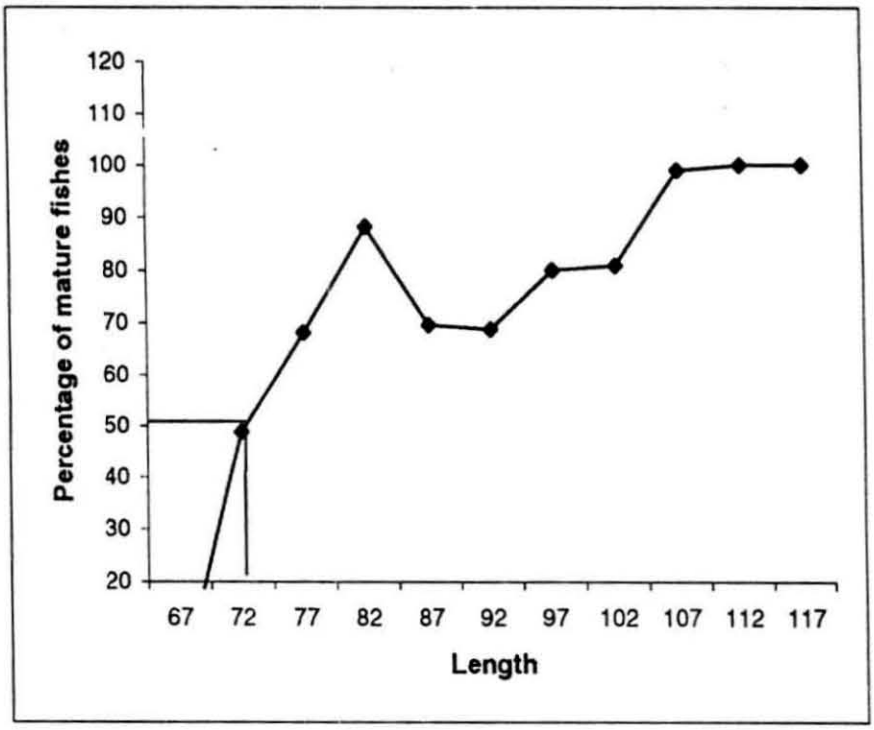



**Fig: 30 Proportion of mature fishes in different length groups in *L.splendens* (Data of one year considered)**

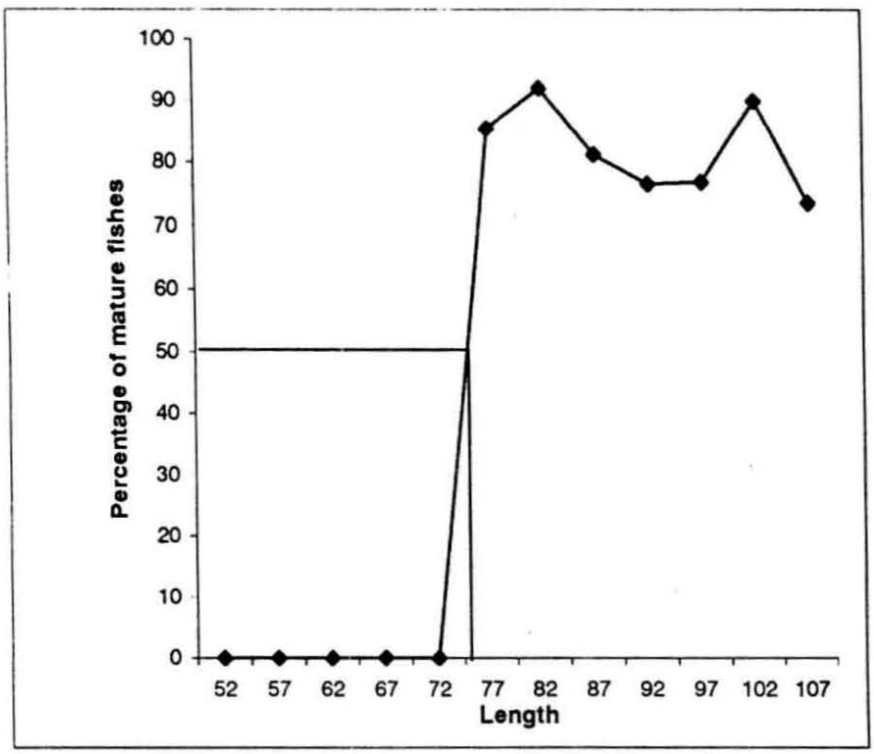



**Fig: 31 Proportion of mature fishes in different length groups in *L.splendens* (Data of October 1998-February 1999 considered)**

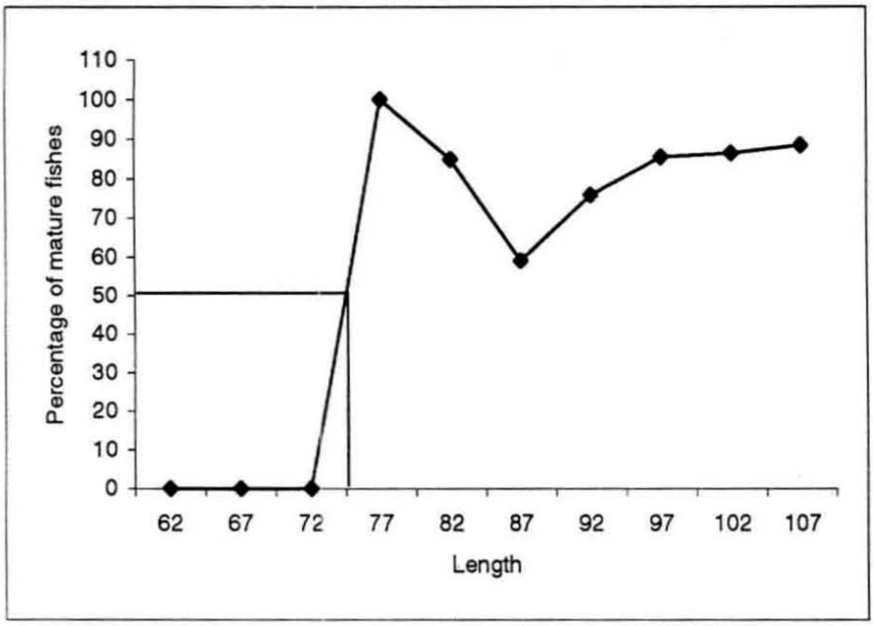



Fig. 32 Proportion of matured fishes in different length groups in S. insidiator data one year considered

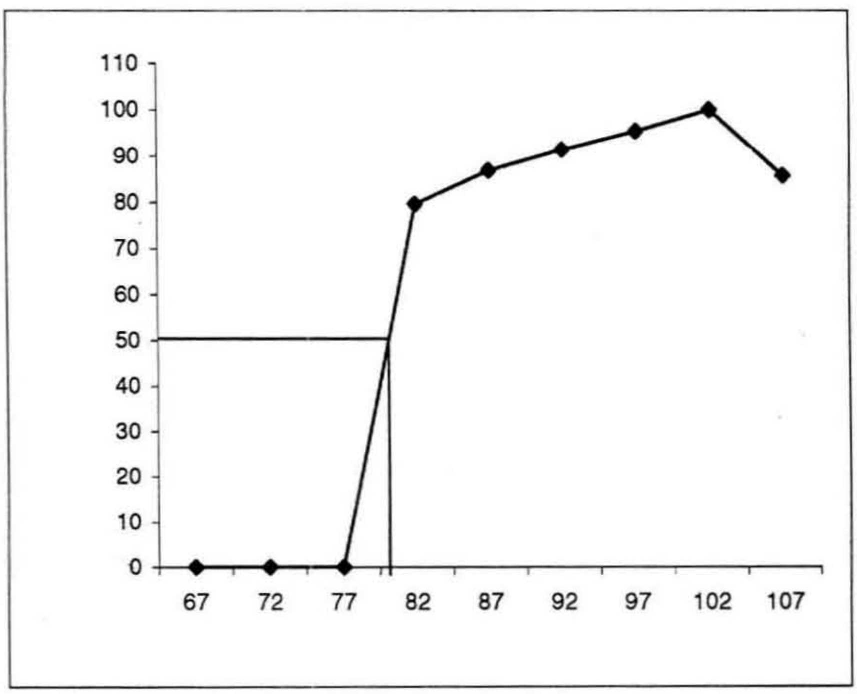



Fig. 33 Proportion of matured fishes in different length groups in S. insidiator data September 99- December 99 is considered

was taken into account for the purpose. The data collected from the Cochin and Neendakara fishing harbours were pooled.

In *Leiognathus splendens*, fishes with mature ovaries occurred in considerable quantities in all months (except June-July when there was trawl ban and August when there was no landing of these fishes) The proportion of mature fishes was above 50% in all the months (Table 4) except April, May and September. In *Secutor insidiator*, gravid adults occurred during all months (Table 5) with percentage occurrence exceeding 90 in March-April and September-December periods. In both the species, fishes with ripe, running stages were rare. This may be due to several reasons; in many marine species the ripe stage is of a very short duration and in some cases lasting only for about a few hours. On the basis of the proportion of mature females of *L. splendens* and *S. insidiator* almost in all months, it is reasonable to conclude that these species have extended spawning period running almost throughout the year.

ii. Gonado-somatic index

Ovary size in fishes increases with stage of development and with fish size or age (Bunag, 1956). If the gonads undergo a regular seasonal change during the year and when this is accompanied with large changes in weight, particularly in females, their seasonal analysis should be indicative of peak spawning activity (Qasim, 1973a). If we take the simple gonad weight: body weight ratio, then its usefulness as an index of gonadal development would be highly reduced, as the size differences in the fish can influence this ratio. The most common means of accounting for the effects of differential body size on gonad size has been to express the gonadal weight as a percentage of body weight.(De Vlaming *et al.*, 1982). This ratio is termed the Gonadosomatic index.

$$\text{Gonado-somatic Index} = \frac{(\text{Gonadal weight})}{(\text{Body weight})} \times 100$$

According to Nikolsky (1963), "the effects of fish size on gonadal weight are eliminated by expressing gonadal weight as a percentage of body

Table. 4 Distribution of females in different stages of maturation in *L. splendens*

| | | Maturity Stages (Percentage) | | | | |
|---|---|---|---|---|---|---|
| **Month** | **No. of females examined** | **I** | **II** | **III** | **IV** | **V** |
| **Oct-98** | 23 | | 2.9 | 8.0 | 89.1 | |
| **Nov-98** | 44 | | 0.3 | 25.6 | 73.2 | 1.0 |
| **Dec-98** | 99 | 0.1 | | 20.2 | 79.6 | |
| **Jan-99** | 103 | | | 11.2 | 76.1 | 12.7 |
| **Feb-99** | 67 | 16.4 | 2.5 | 16.1 | 65.0 | |
| **Mar-99** | 132 | 9.6 | 2.2 | 12.2 | 76.0 | |
| **Apr-99** | 130 | 51.3 | 6.7 | 4.0 | 37.5 | 0.6 |
| **May-99** | 32 | 72.0 | 10.0 | 4.6 | 13.4 | |
| **Jun-99** | 40 | 46.5 | 12.6 | 41.0 | | |
| **Jul-99** | | | No fishing | | | |
| **Aug-99** | | | No landings | | | |
| **Sep-99** | 30 | 53.9 | | 8.7 | 37.4 | |
| **Oct-99** | 100 | 38.7 | | 7.8 | 53.5 | |
| **Nov-99** | 80 | 19.7 | | 2.8 | 77.1 | 0.4 |
| **Dec-99** | 102 | | | 8.6 | 90.8 | 0.6 |

Table. 5 Distribution of females in different stages of maturation in *S. insidiator*

| | | Maturity Stages (Percent) | | | | |
|---|---|---|---|---|---|---|
| **Month** | **No. of females examined** | **I** | **II** | **III** | **IV** | **V** |
| **Oct-98** | 29 | | | 52.8 | 47.2 | |
| **Nov-98** | 33 | | 0.3 | 12 | 87.7 | |
| **Dec-98** | 40 | | | 44.3 | 55.7 | |
| **Jan-99** | 173 | 1.9 | 0.3 | 58.3 | 39.6 | |
| **Feb-99** | 39 | 2.4 | | 25.8 | 71.8 | |
| **Mar-99** | 82 | 0 | | 9.5 | 90.5 | |
| **Apr-99** | 96 | 1.1 | | 5.1 | 92.2 | 1.6 |
| **May-99** | 25 | | | | 100 | |
| **Jun-99** | 34 | 24.9 | 16.1 | 46 | 13 | |
| **Jul-99** | | | No fishing | | | |
| **Aug-99** | | | No landing | | | |
| **Sep-99** | 28 | | | 7.8 | 92.2 | |
| **Oct-99** | 78 | 2.5 | | 3.1 | 94.4 | |
| **Nov-99** | 72 | 0.9 | | 7.3 | 91.9 | |
| **Dec-99** | 57 | | | 9.2 | 90.8 | |

weight". In work with fishes, the GSI is widely used as an index for spawning preparedness (De Vlaming *et al.*, 1982).

The earliest use of ovary weight relative to fish weight as a measure of maturation was by Hoek (1895), cited in June (1953). De Vlaming *et al.*, (1982) reviewed the use of gonadosomatic index and listed the various assumptions underlying it.

In the present study, gonado-somatic index was used to corroborate the spawning period as estimated from the method of percentage occurrence of maturity stages. For the studies on gonadosomatic index, only fishes, above the length at first maturity were considered for both the species.

The gonado-somatic index for the different maturity stages of *L. splendens* and *S. insidiator* are presented in the table below.

Gonado-somatic Index in fishes of different stages of maturation

(Average values with the standard deviation)

| Stages of Maturity | *L. splendens* | *S. insidiator* |
|---|---|---|
| I | 0.2235 ± 0.2097 | 0.4049 ± 0.2923 |
| II | 0.2967 ± 0.2631 | 0.3142 ± 0.1723 |
| III | 1.2673 ± 1.0560 | 1.4308 ± 0.7804 |
| IV | 2.5061 ± 1.5801 | 2.3546 ± 0.7832 |
| V | 2.9723 ± 2.1467 | 2.9164 ± 0.4889 |

It can be seen that the average value in *L. splendens* varies from 0.2235 in stage I females to 2.9723 in ripe females. In *S. insidiator*, the same increases from 0.4049 in stage I females to 2.9164 in stage V females.

The average monthly gonado-somatic index (pooled data of Cochin and Neendakara), plotted against the respective months (Figs. 34&35) shows that in *L. splendens*, the value is high during December 1998 - January 1999 and

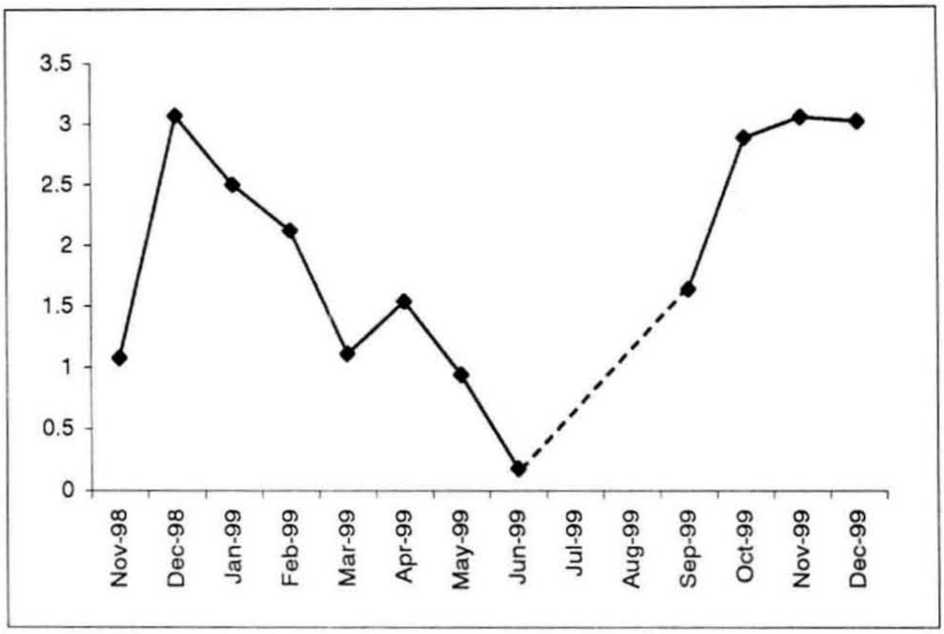



Fig: 34 Gonado-somatic Index in females of *L.splendens* in different months

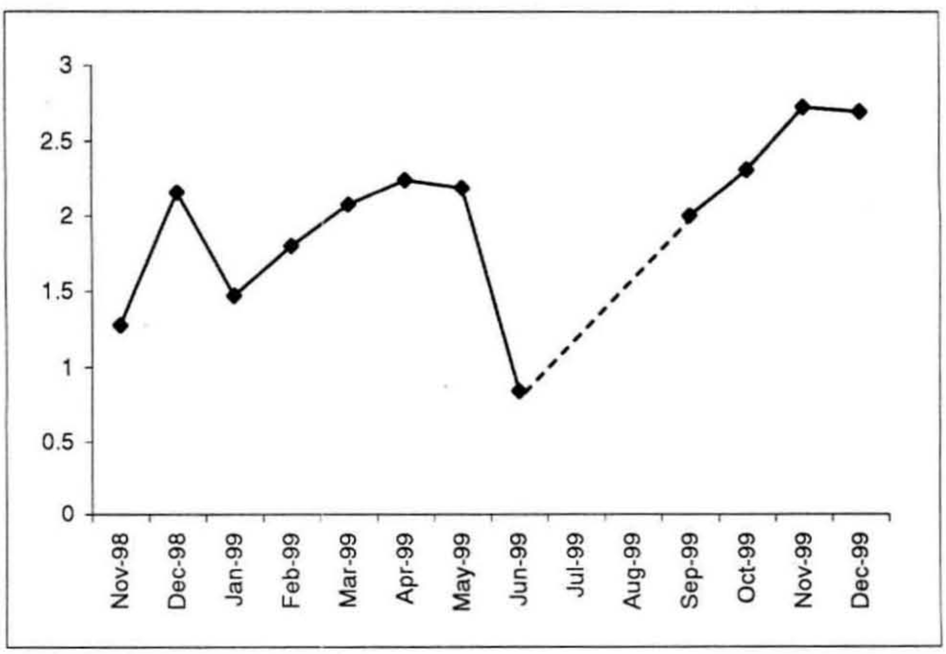



Fig: 35 Gonado-somatic Index in females of *S. insidiator* in different months during November 1999-Dec 1999, corresponding to the months of peak spawning.

In *S. insidiator*, the gonado-somatic index shows high values during March 1999 – April 1999 and September 1998- December 1998, coinciding with the peak periods of spawning activity.

**C. FECUNDITY**

Fecundity is defined as " the number of ripening eggs in the females prior to the next spawning period." (Bagenal, 1968). It is estimated for a number of purposes, as part of systematics in racial studies, in connection with total population estimation or in studies of population dynamics or productivity (Bagenal, 1968). For all practical purposes the fecundity per year is necessary because all other population estimates are made on per year basis.

The estimated fecundity ranges from 5715 in a fish of 88 mm TL to 37160 in a fish of 106 mm TL. The variation in fecundity is considerable even within each length group. The data were analysed to fit regression lines of fecundity on total length, fecundity on body weight and fecundity on ovary weight. Since the scatter plots (Fig. 36-41) in these three instances do not reveal clearly the type of relationship, both linear and exponential equations were fitted to the observed data, using the least squares method (Snedecor and Cochran, 1967). The details are given in Table 6.

Table 6. Estimated values of slope and elevation by fitting exponential and linear regression in *L. splendens*

| | Exponential $Y=aX^b$ | Linear $Y=a+bX$ |
|---|---|---|
| Fecundity against length | a = 0.088823,<br>b = 2.621592, $R^2$ = 0.2588 | a = -24669.53152<br>b = 419.96479, $R^2$ = 0.2241 |
| Fecundity against body weight | a = 1521.391<br>b = 0.865752, $R^2$ = 0.2519 | a = 1569.73024<br>b = 1061.26097, $R^2$ = 0.20865 |
| Fecundity against ovary weight | a = 20832.985<br>b = 0.578570, $R^2$ = 0.2603 | a = 7840.970981<br>b = 14463.2401, $R^2$ = 0.13117 |

The $R^2$ value in each case reveals that the regression in both cases do not explain the correlation (Fig. 36-41) well. Then, the average values of fecundity of fishes of each length group (Table 7) were regressed against the corresponding average length, body weight and ovary weight (Fig. 42-47). Interestingly, however, the $R^2$ values in these cases, suggest the possibility of a curvilinear relationship.

## DISCUSSION

A survey of the literature on maturation of fishes reveals that no standard set of maturation stages could be assigned to the ovaries of all oviparous teleosts because species in the different geographical regions show considerable variation in the annual maturation cycle of intraovarian eggs. In most of the temperate zone fishes and some freshwater fishes of India like the carps, which have a short and distinct spawning season, all the eggs in the ovary at any one moment are at approximately the same state of development. In these fishes all the ova to be spawned in a season mature simultaneously and are released in one spawning act as in the herring (Hickling, 1940) or some cyprinid fishes of India. In those fishes, which have prolonged spawning seasons, the ovaries include several batches of eggs destined to mature and shed periodically (Qasim, 1956). In these fishes exemplified by some tropical marine fish species, the ovaries contain eggs in a more or less continuous range of development stages and the ova may mature in two or more batches, to be released also in two or more batches (fractional spawning) in a year. In tropical fishes which are perennial breeders, almost all conceivable stages of maturity occur in the population throughout the year (Qasim 1973a) and it would be unrealistic to attach a single unique maturity stage to these fishes (Bagenal, 1968), and hence any classification of maturity based on the models of temperate water forms cannot be applied with any degree of certainty to the tropical species.

Seven stages of maturity, as determined according to the maturity scale adopted by the International Council for the Exploration of the Sea, were assigned by Wood (1930) for the herring. These stages have been uncritically

Fig. 36 Plot of estimated values of fecundity against length in *L. splendens* and fitting curvilinear relationship

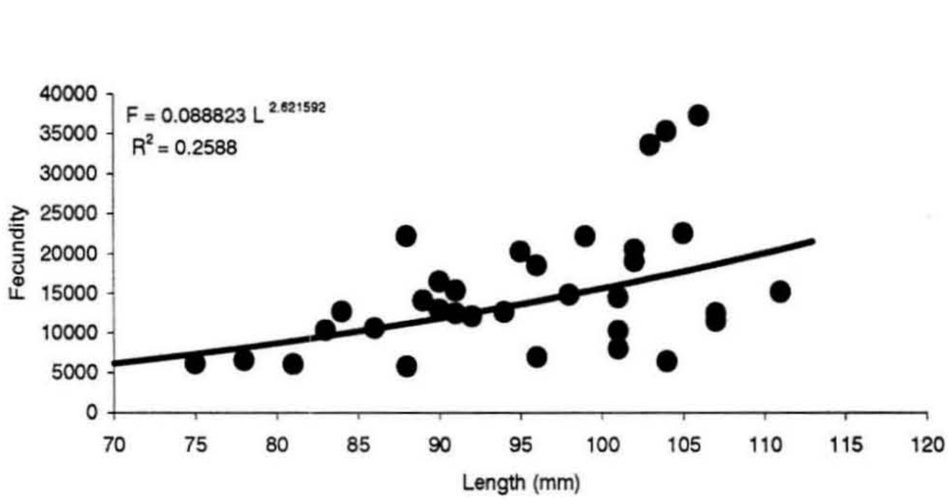



Fig. 37 Plot of estimated values of fecundity against body weight in *L. splendens* and fitting curvilinear relationship

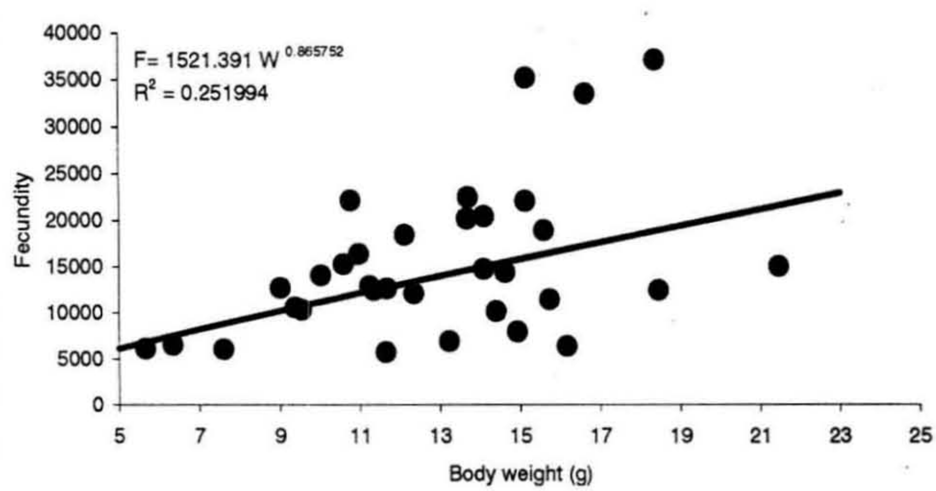



Fig. 38 Plot of estimated value of fecundity against ovary weight in *L. splendens* and fitting curvilinear relationship

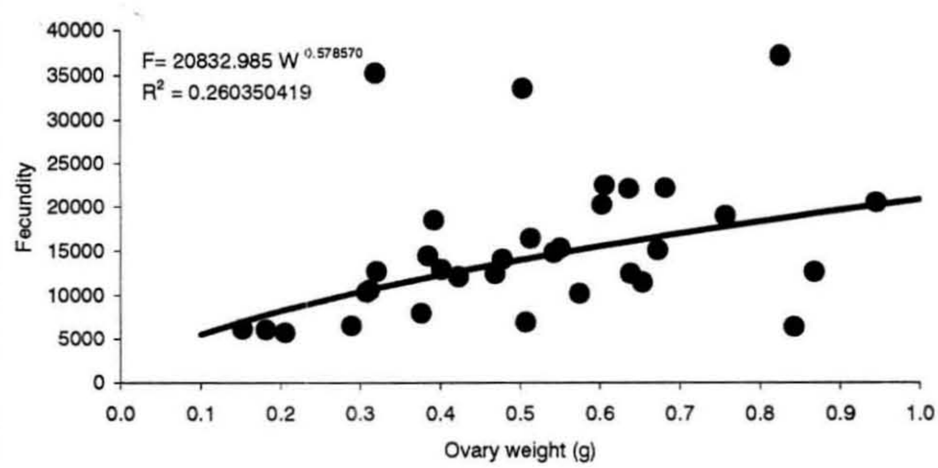


Fig. 39 Plot of estimated values of fecundity against total length in *L. splendens* and fitting linear relationship

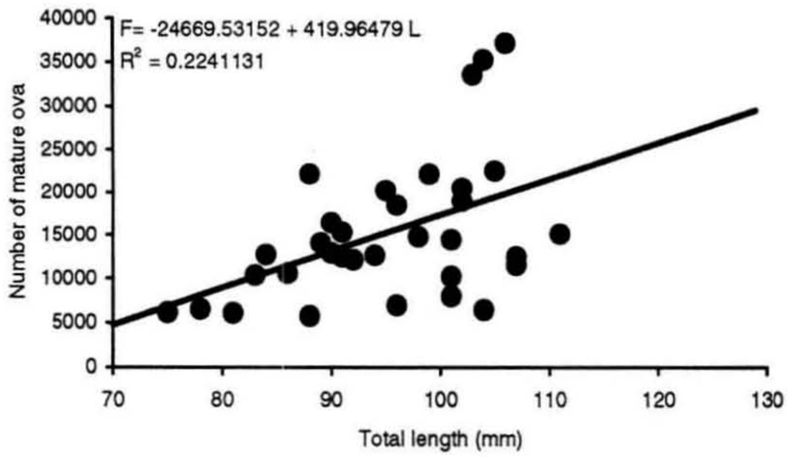



Fig. 40 Plot of estimated fecundity against total body weight in *L. splendens* and fitting linear relationship

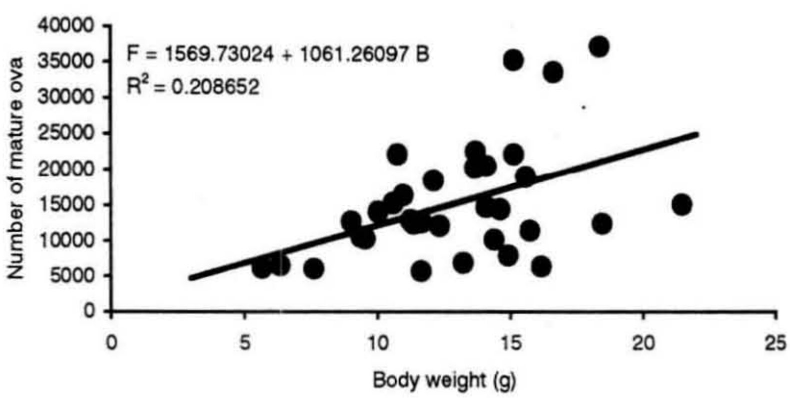



Fig. 41 Plot of fecundity against ovary weight in *L. splendens* and fitting linear relationship

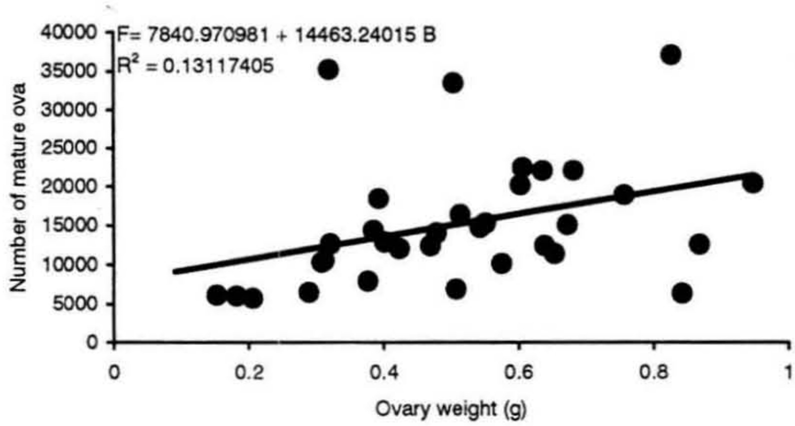


Fig. 42 Plot of estimated values of fecundity (average) against length (average) inL. splendens and fitting curvilinear relationship

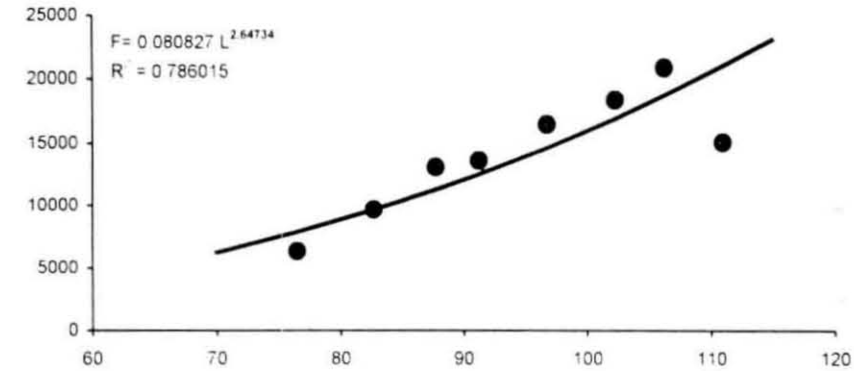



Fig. 43 Plot of estimated values of fecundity (average) against body weight (average) in L.splendens and fitting curvilinear relationship

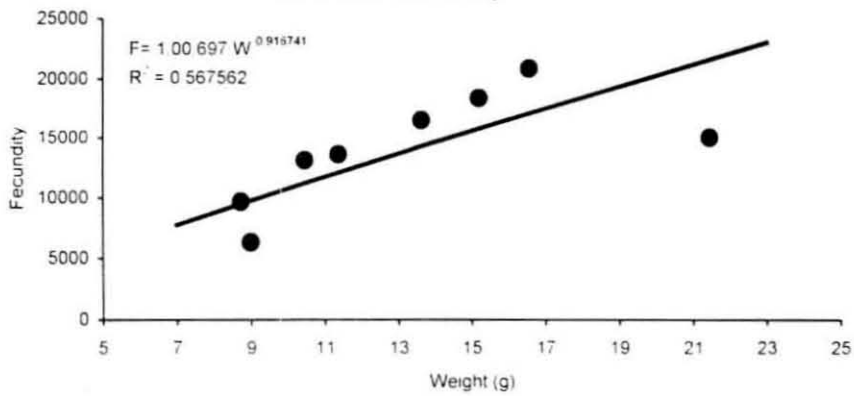



Fig. 44 Plot of estimated values of fecundity (average) against ovary weight (average) in L. splendens and fitting curvilinear relationship

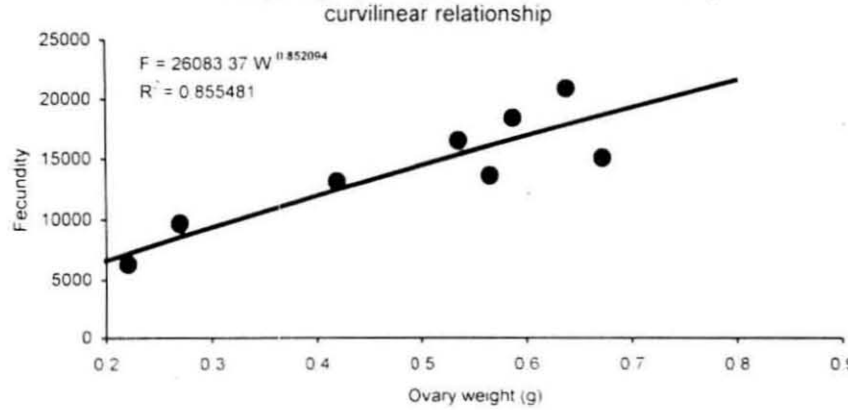


Fig. 45 Plot of fecundity (average) against total length (average) in *L. splendens* and fitting linear relationship

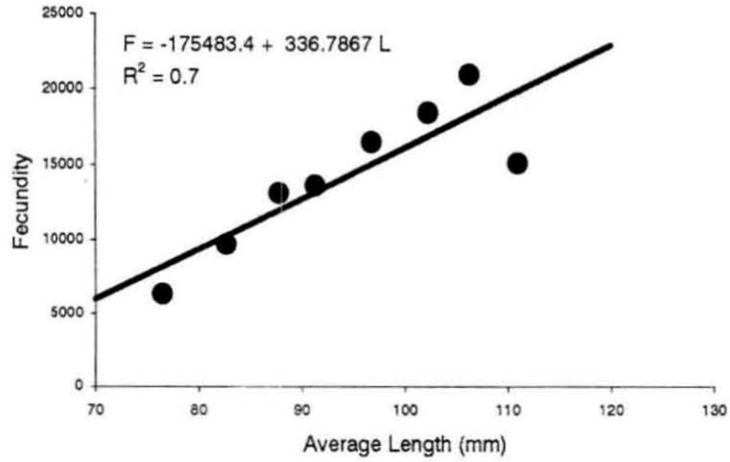



Fig. 46 Plot of fecundity (average) against total body weight (average) in *L. splendens* and fitting linear relationship

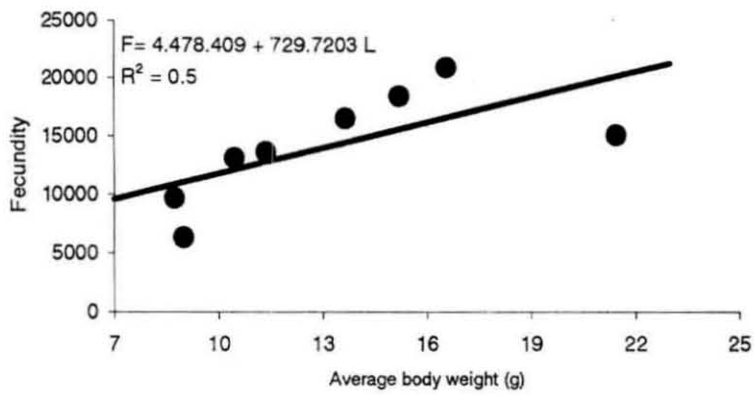



Fig. 47 Plot of fecundity (average) against ovary weight (average) in *L. splendens* and fitting linear relatioship

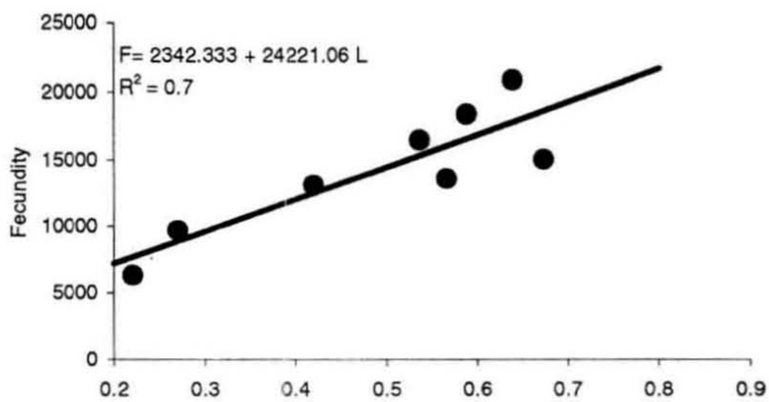


Table 7. Estimated average fecundity of *Leiognathus splendens* in different length groups

| S.No | Length groups (mm) | Average Length (mm) | Average body weight (g) | Average ovary weight (g) | Estimated average fecundity |
|---|---|---|---|---|---|
| 1 | 75-79 | 76.5 | 9.00 | 0.2209 | 6316 |
| 2 | 80-84 | 82.7 | 8.73 | 0.2703 | 9673 |
| 3 | 85-89 | 87.8 | 10.46 | 0.4194 | 13110 |
| 4 | 90-94 | 91.3 | 11.37 | 0.5659 | 13607 |
| 5 | 95-99 | 96.8 | 13.65 | 0.5363 | 16482 |
| 6 | 100-104 | 102.3 | 15.21 | 0.5881 | 18382 |
| 7 | 105-109 | 106.3 | 16.57 | 0.6388 | 20873 |
| 8 | 110-114 | 111 | 21.46 | 0.6729 | 15063 |

used by several Indian workers (Seshappa and Bhimachar, 1955, for malabar sole; Pradhan and Palekar, 1956, for *Rastrelliger kanagurta*; Dharmamba, 1959, for some clupeoids, Varghese, 1961, for *Raconda russeliana*, Sam Bennet, 1967, for *Sardinella fimbriata,* Devadoss, 1969, for *Otolithus ruber* , Marichamy, 1970 for the anchovy, *Thrissina belama*, Antony Raja,1969, for Indian oil sardine, Kagwade,1971, for *Selar kalla,* Luther,1986, for *Chirocentrus)* to describe the maturity stages of fishes that are fractional spawners with prolonged spawning seasons, though this scale was primarily developed for a fish of the temperate waters, with a short and restricted spawning period. Rao, 1967c, James, 1967, Jhingran, 1961 and Deshmukh, 1973, also adapted this scale with slight modifications.

Considering the problems associated with the quantification of the maturity stages, Qasim (1973a) suggested a five-point scale for quantifying the gonads into maturity stages of tropical and sub-tropical fishes. These are, I. Immature virgins, II. Maturing virgins or Recovered spents, III. Ripening, IV. Ripe and V. Spent. Since the spent gonads are not found in the population of continuous breeders and the chances of getting a perfectly ripe fish would also be remote, as before the ovary turns fully ripe, a part of it is spawned, he (Qasim, 1973a) considered that it was desirable to include only three stages for the continuous breeders as, I. Immature II. Maturing III Ripening.

A survey of literature on the classification of maturity stages in silverbellies reveals that except Arora (1952) who recognised only three stages of maturity in the ovaries of *L. splendens,* all the subsequent workers (Balan, 1963, Rao, 1967a, James and Badrudeen 1975, James, 1986, Jayabalan, 1986, 1988 and Jayabalan and Ramamoorthi, 1985c) followed a seven-point scale of maturity in the silverbellies. Murty, (1983), followed the maturity classification of James and Badrudeen (1975), for *L. bindus*.

In view of the inadequacy of the available scheme of classification, a separate scale of five stages has been developed for quantifying the gonads of *L. splendens* and *S. insidiator* in the present study on the basis of external appearance of the ovaries, the ova diameter frequency distribution and the microscopic structure of the intraovarian ova for the former and based only on the basis of external appearance of the gonads for the latter. The 'spent' stage has not been designated here since no such ovary was encountered in the present collections.

There is need to recognise that the scale of maturation stages is not a physical entity but a biological scale which is different in different groups of species and in different regions. It also needs to be recognised, particularly in the Indian marine fishes that a unique stage of maturation cannot be attached to any ovary after maturation starts because such ovaries contain ova in different stages of maturation. The present study reveals that a clear, distinguishable scale has to be developed for each species on the basis of the presence of most advanced ova in the ovary besides the external appearance and size of ovaries. This has been done in the present study.

The ova diameter frequency distribution of *Leiognathus splendens,* shows an immature group of ova forming a single mode in Stage I fishes. In the ovaries of stage II, the mode shifts further. The ova are similar in stages I and II, the stage II ova being larger than the stage I ova. The single mode at 28.5 m.d. in the stage III ovary represents a definite advancement in the size and structure of the ova. The ova increases in size rapidly, probably due to accumulation of yolk. In the mature ovary of stage IV female, a single mode is present at 33 m.d., sharply separated from the immature group of oocytes. In the ripe or stage V ovary, two modes are present, one containing maturing and mature oocytes with the mode at 24-27 md and the other containing only mature and ripe oocytes with the mode at 45-48 md.

According to De Jong (1940) the conditions in the tropical seas make it probable that specimens, which contain ripe ovaries, will be found throughout the year, so that a periodicity in the individual may be obliterated in the species as a whole. However, he remarks that, although fishes with ripe ovaries may be found in every season, the species as a whole may show a rather definite periodicity. From the ova diameter frequency distribution it may be concluded that *L.splendens* is a continuous spawner, spawning eggs in batches over an extended spawning season.

According to De Jong (1940) "... in the ovary of the adult fish we find a stock of small, yolkless eggs... ....from this general egg stock, quota are withdrawn to be matured and finally spawned." A similar observation has been made in the present study, with the quota of immature eggs being present in all stages.

Arora (1952) estimated the length at first maturity of *L. splendens* from Rameswaram, by considering the fish collected only during the period of peak spawning. In his study all the females above 68 mm in length were found to be mature; he stated that *L. splendens* matures first at an average length of 60 mm or at the end of the first year of its life. Jayabalan (1986) reported that in *L. splendens* from Port Novo, mature females first appear in the length group 76-80 mm and all the females above 111 mm were fully mature. Hence females were taken to mature at any length between 76 and 111 mm total length. This result is comparable with the present study in which length at first maturity of *L. splendens* was estimated at 75 mm TL, wherein, only the peak spawning season was considered for the estimation.

In *S. insidiator* from Port Novo, length at first maturity was estimated as between 76 and 91 mm for females (Jayabalan and Ramamoorthi, 1985c), since all females up to 75 mm were immature and all the fishes above 90 mm were in mature condition. Murty (1990) estimated the length at first maturity for *S. insidiator* to be 90 mm, with mature gonads being seen in fishes of length 72 mm onwards. The present study revealed that 50 % of females of *S. insidiator* were mature at a length of 80 mm.

For the estimation of length at first maturity, it is necessary to consider data collected during the period when maximum number of mature adults occur in the catch (i.e. the population) so that the estimated length is not affected by time (i.e. growth). The literature on this subject in India reveals that almost all the workers used the data collected over a period of time for this purpose. The estimates of $L_{50}$ obtained thus may not be reliable because:

⇒ most of the fishes during non spawning period will not be in mature condition resulting in over representation of immature and maturing fish (which are relatively smaller) in the samples

⇒ in cases where spawning period is restricted to a short period there is a possibility of considering adults (even those which spawned once) as immature

More over, the estimate under consideration is "Length" and specimens of a particular length group collected in different months (including non spawning periods) are all included under the same length group. However fishes of certain lengths collected in the beginning of the year would reach larger lengths over time and this is not taken into account. Hence to prevent the growth influencing the estimate of length at first maturity, it is desirable to consider data as short a period as possible for purpose of this estimation. In the present study, the periods during which maximum number of mature fish occurred in the landings were considered besides the data obtained throughout. There is only a difference of 5mm in the estimates. Since the species considered are small, the difference has not been very significant. It is expected that in species attaining larger lengths, the difference in the estimates is bound to be larger and the estimate obtained on the basis of data of shorter period would be most reliable.

On the basis of the observation that there are two distinct groups, one of maturing ova, and another of ripe ova in a ripe ovary, in *L. splendens* Jayabalan (1986) concluded that the spawning is restricted to a short period and that it spawns twice in a season. James and Badrudeen (1986), indicated that the species spawn in batches in quick succession over a short period based on the presence of two distinct modes of large ova, one following the other in the ova diameter frequency curve for stage V –VI. Arora (1952) concluded that *L. splendens* spawns more than once in a season, based on the presence of both maturing and mature eggs in the ripe ovary. The present study however suggests that L. *splendens* spawns continuously in a season at intervals, but the time gap cannot be stated.

Most of the accounts of the spawning season of *L. splendens* are from the East coast. According the Arora (1952), the spawning season of *L. splendens* in Rameswaram extends from March – August with peak in April and August. Jayabalan (1986) concluded that *L. splendens* spawns throughout the year with peaks in April- May and October- January along the Port Novo coast. Rao (1967a) indicated a prolonged spawning at Madras with peaks in January, February and June. Kuthalingam (1958) was able to collect large number of juveniles during September- December from Madras. The only probable conclusion about the spawning of *L. splendens* from the West coast is given by Bhimachar and Venkataraman (1952) who obtained post larvae and immature specimens of the species during April- June and December- March, with a peak in March, from Calicut. In the present study, based on the presence of mature ovaries in almost every month, it can be concluded that *L. splendens* has a prolonged spawning period, extending almost throughout the year. Studies on the spawning biology of *S. insidiator* are few and absolutely no information is available on the biology of the species from off the West coast. Mahadevan Pillai (1972), indicated a prolonged spawning period for *S. insidiator* confirmed by the presence of juveniles in shore seine catches for most part of the year. Jayabalan and Ramamoorthi (1985c) from the study of the percentage occurrence of different stages of maturity of female gonads indicated that the spawning of *S. insidiator* takes place between July and November and again during March and April. James and Badrudeen (1986) concluded from the ova diameter frequency curve of the mature ovary that in *S. insidiator,* the maturation process is continuous and that the species is likely to spawn over a prolonged period. Murty (1990) was also of the same opinion, asserting that the spawning season is protracted, running almost throughout the year, with a peak during the January to March period. It may be concluded from the data obtained that the species, L. *splendens* and *S. insidiator,* in Kerala are having a protracted spawning season extending almost throughout the year.

Since adequate samples were not available during the monsoon months, a definite conclusion about whether the species spawns during the monsoons also, couldn't be arrived at. The same problem was confronted by Arora (1952) at Rameswaram during the months of December, January and February when the fishery was non-existent.

However the estimated recruitment pattern (Fig. 86,87,88,89&90) in these species clearly shows round the year recruitment, which can only result out of round the year spawning.

Estimation of fecundity is relatively easy in the temperate species which exhibit a short and definite spawning season, and in which the mature eggs destined to be spawned are clearly separated from the stock of immature developing oocytes; but in many tropical fishes, in which the ovaries show a series of batches of intra-ovarian eggs (multiple, partial, serial or heterochronal spawners), it is not possible to estimate annual fecundity. In such fishes, the standing stock of yolked eggs regardless of maturity state give no indication of annual fecundity, because these fishes continuously mature new spawning batches through a typically protracted spawning season (Hunter *et al.*, 1985). The problems to be considered here are estimating the number of eggs actually shed in a spawning season and also estimating the number of batches in which these eggs are released. The major problem in estimating fecundity of multiple spawners is to identify the oocytes to be included in a spawning batch. A number of criteria for identifying the oocytes to be spawned have been suggested by Hunter *et al.*,(1985).

Hickling and Rutenberg (1936), showed that in herring, the eggs destined to be spawned in the current season are ripened simultaneously and there is a sharp separation; in point of size between the active yolky eggs and the small yolkless ones. Bagenal (1966) mentioned the presence of 2 kinds of developing eggs in the ovaries of the Plaice *Pleuronectes platessa* L., before the onset of the spawning season. One set are minute and white which develop in the subsequent years, while the other set are opaque, larger, yolk laden ova, that will be shed in the coming breeding season, and only the latter were counted when determining the fecundity. Antony Raja (1971) in his investigations on the fecundity fluctuations of the oil sardine, *Sardinella longiceps* calculated the fecundity by estimating the number of ova in the principal mode (above 0.45 mm in the ova diameter frequency polygon). Krishna swarup (1961) discovered the presence of two types of ova in the Indian shad, *Hilsa ilisha*, mature ova (0.6-0.9mm) and greater numbers of immature ova (0.03-0.3 mm), and on account of so great a separation in size, only the former was measured for estimating fecundity. A notable study on the fecundities of some freshwater fishes is that of Quasim and Qayyum (1963) who have determined the fecundity of 3 species from ponds near Aligarh. In *Ophiocephalus punctatus* (Bloch), which bears more than one group of maturing ova in the ovaries, they counted the "large ripe eggs" forming the bulk of the ovary. In *Callichros pabda* (Ham. Buch.) and in *Mystus vittatus* (Bloch), whose ripe ovaries contain one group of uniformly large ova that can be distinguished from the much smaller yolkless ova, fecundity was estimated by counting only the former.

Present study is based on the examination of mature ovaries of 33 specimens of *L. splendens* ranging in length from 75 mm to 107 mm collected during the spawning season from October to March from the study area. Ovaries in the penultimate stage of maturity ie, stage IV, only were taken for fecundity estimation. The ova to be counted were determined from the ova-diameter frequency polygons of the St. IV ovaries.

In the present study the fecundity was estimated using 33 specimens of *Leiognathus splendens.* All the mature (type III) ova were counted for fecundity estimation. The fecundity varies from 5715 ova in a specimen of 88 mm standard length with an ovary weighing 0.206 g to 37160 ova in a specimen of 106 mm standard length, with an ovary weighing 0.826 g. Fishes of the same length and length group are seen to show wide variations in fecundity, as for example, the estimated fecundity of two specimens of 104mm length is 6370 to 35241. It is known that the number of mature ova increases with increase in fish length as shown by Jayabalan and Ramamoorthi (1985c) in *Secutor insidiator* and Jayabalan (1986) in *L. splendens.* James and Badrudeen, 1986 however reported a decrease in fecundity with length in L. *splendens* and increase in fecundity with length in *Leiognathus bindus, S. insidiator*, *Leiognathus berbis, L. brevirostris, L. daura and Secutor ruconius*

The earlier report from the Indian waters on the fecundity of *L. splendens* is that of Arora (1952) from Rameswaram, Jayabalan (1986) from Porto Novo and James and Badrudeen (1986), from Palk Bay. Arora examined a small length range only and estimated a fecundity of 10588 ova for a fish of

74 mm length, showing comparatively high values of fecundity for fishes of comparable length ranges in the present study, while Jayabalan (1986) reported a fecundity of only 21507 ova for a fish of 119 mm length, which is low. Considering the wide range in fecundity even for fishes of the same length range, as shown in the present study, the comparison of fecundity as made above does not lead to any conclusion.

From the low $R^2$ values obtained for all the three relationships (i.e. regression of fecundity on total length, total weight and ovary weight) it can be concluded that a curvilinear or linear regression does not explain the relationship. The relationship log Y = a + b log x was used by Jayabalan and Ramamoorthi (1985c) to fit the regression of fecundity on length and weight of *S. insidiator* from Port Novo coast. According to James and Badrudeen (1981) and James (1986) the exponential relation explains the relation between fecundity and length in *L. dussumieri* and *L.jonesi* and respectively.

The apparent absence of correlation between fecundity and the three independent variables (*Vide Supra*) as revealed by poor $R^2$ values could be due to the random variations in fecundity. However, it needs to be noted (*Vide Supra*) that this species spawns in batches during the course of a year and the batch sizes are likely to be different in different batches in fishes of different lengths. More over in the population at any one time, fishes spawning for the first time, second time, third time, and so on are also likely to be present. It may be recalled that after spawning the first batch, the fishes continue to spawn at different intervals; naturally one would expect a wide difference in the batch sizes. It is believed that this situation has led to the absence of correlation (very low values of $R^2$) between fecundity and length, body weight and ovary weight as otherwise one would expect a significant correlation between these variables. It may be noted, however, that the $R^2$ values are 0.78 for average fecundity against average length, 0.56 for fecundity against total weight and 0.85 for fecundity against ovary weight, when an exponential equation was fitted, suggesting the possibility of the existence of curvilinear relationship between these variables.

# Chapter III

# Growth

# GROWTH

A sound knowledge of the growth and age of fish species contributing to the fishery is essential for understanding, among others

1. The longevity of exploited stocks
2. The age composition of the catch
3. The age at sexual maturity
4. The suitability of different environments for growth
5. The population dynamics and for
6. The possible identification of stocks on the basis of differences in growth rates



According to Qasim (1973b), the main purpose of the study of growth is to determine the amount of fish that can be produced in terms of quantity (weight) in a body of water in relation to time.

A number of workers have attempted a study of age and growth in Indian silverbellies. Some works pertaining to the same are Murty (1983,1986a) on *L. bindus* off Kakinada, Jayabalan (1988) on *L. splendens* off Porto Novo, Jayabalan and Ramamoorthi (1986) on *G. minuta* from Porto Novo, Karthikeyan *et al.* (1989) on *L. Jonesi* from Rameswaram, Murty *et al.* (1992), on some silverbellies of Andhra Pradesh and Tamil Nadu, James and Badrudeen (1975) on *L. brevirostris* from the Palk Bay and Gulf of Mannar, Arora (1952), on *L. splendens*, off Rameswaram and Balan (1963) in *L. bindus* from Calicut. A survey of the above literature reveals that all the studies are based on the length frequency distributions of fishes collected monthly. No attempt has been made to read the age from hard parts, excepting the work of James (1986) on *L. jonesi* and James and Badrudeen (1981) on *L. dussumieri*, where the supra-occipital bones and cleithrum were used for reading the age. However the results are inconclusive.

## METHODS OF STUDY OF GROWTH

A large number of studies on temperate fishes have contributed towards standardising the various methods for age and growth studies. Most of these methods have been described and discussed by Lagler (1956) Rounsfell and Everhart (1953), Chugunova (1963) and Tesch (1968).

The methods of age determination are grouped under four categories.

i. *KNOWN AGE METHOD:* Involves rearing the fish from early larval stage in a holding facility simulating the natural conditions, so that optimum growth is achieved, but this is not possible in all exploited species and is capital intensive.

ii. *TAGGING OR MARKING:* A direct and positive method of determining the growth of fishes is by the process of releasing and recovery of a tagged or marked fish (by clipping part of the fin or punching part of the operculum). It has to be assumed that the tagged fish behave and grow normally. Some marking and tagging methods suffer from the handicap that the marked fish may grow slowly (Tesch, 1968). Moreover recoveries are seldom reported. This method is again costly and time consuming, and is almost impossible in the case of small fishes.

iii. *USE OF HARD PARTS:* A characteristic feature of the growth of fish is its periodicity (Nikolsky, 1963). Under temperate conditions, almost all fishes have annual cycles of maximum growth corresponding to summer and autumn when temperature and food supply are optimum and growth is minimum in winter and spring when both the temperature and food supply are low (Qasim, 1973b). This unevenness in growth rate is reflected on the hard parts in the form of growth checks, which are formed during the period of slow growth. The growth checks were reported on scales, otoliths, opercular bones, fin spines and vertebrae. Since these growth checks are formed once a year they have been variously termed annual rings, annual marks, year marks or winter checks. The validity of these zones, even in temperate waters has often been questioned and in certain situations the age reading was found to be unreliable (Qasim, 1973b). Generally, age as determined from such growth checks is compared with the results obtained by the analysis of the length data for verifying the results.

Compared to the temperate forms, the fishes of tropical and sub-tropical waters, like those of the seas around India live in totally different conditions. In tropical waters, neither temperature nor food supply vary considerably with seasons and hence to expect that the growth will follow a cyclic or annual pattern similar to that of temperate waters holds little ground (Qasim, 1973b).

In tropical waters, it is yet to be established that growth checks on the hard parts, are useful in determining the growth and age. Available data indicate that the growth checks observed in tropical species are attributed to different causes; paucity of food during monsoon, in malabar sole (Seshappa and Bhimachar, 1955) and in grey mullets (Sarojini, 1957), to starvation, in mrigal (Jhingran, 1959; Kamal, 1969) and ghol (Rao, 1962), to spawning stress in Catla (Natarajan and Jhingran, 1964) and in Indian mackerel (Seshappa, 1958, 1972), and to food of low nutritive value plus spawning stress in the freshwater catfish *Pangas* (Pantulu, 1962).

A number of reviews have been made on the method of age determination, particularly with reference to temperate fishes: Lee (1920), Hutton (1929), Creaser (1926), Graham (1929) and Van Oosten (1929). In tropical fishes, Menon (1953) and Murty (1976) reviewed the knowledge of the subject. Murty (1976) deduced evidence to show that though well-defined growth checks (comparable to that of any temperate fish) occur in a carp species, they are not reliable in age determination.

*iv. LENGTH FREQUENCY DISTRIBUTION*: The use of length frequency distribution to study growth and age is based on the assumption that when the spawning season of fish is short, seasonal and well synchronised throughout the population, the length composition of the population will show distinct modes corresponding to year classes (Qasim, 1973b). It is known that the frequency analysis of the individuals of a species of any one age group collected around the same date will show variation around the mean length according to normal distribution and that when data on a sample length frequency distribution of the entire population are plotted, the normal curves for successive age groups will be recognisable, thereby enabling their separation.

The basic pre-requisites for good results by length-frequency method are that the samples used should be composed of large number of individuals and taken from non-selective gear in the area of maximum abundance.

The length-frequency method, though often adequate for the early years of life, has failed to separate reliably the older age groups, because of increased overlap in the length distribution, due to slower growth rate of older fish.

If the spawning season is extended, as in the case of most of the tropical marine fishes, there would be more than one brood (often several closely following broods), and the length frequency distribution of each year class would form a bi-modal or often a multimodal curve and it becomes increasingly difficult to follow the identity and growth history of broods involved, throughout the period of growth.

Four approaches are available for the analysis of length frequency data.

*a. Petersen Method:* Involves attribution of selective ages to the distinct peaks of a single multi-peaked length-frequency distribution. Identifying the 'real' peaks representing the different broods and attributing the proper relative age to them is the main problem in this method. This is quite easy in fishes which have a short and well-defined spawning period and modes in the length frequency distribution represent age groups separated by one year.

*b. Modal Class Progression Method:* The Petersen's method becomes less reliable in cases where the fish spawns over an extended period in batches. In these cases the modes in the length-frequency distribution represent the broods that enter the fishery in close succession. In these cases the modal progression method is followed. In this method, the individual peaks are followed through a time series, by linking the peaks of length-frequency distribution of samples observed at regular intervals. The length-frequency distribution of a number of samples, generally at monthly intervals are studied to trace the progression of modes. The progression of modes in different months over a period of time gives an idea of the growth of different broods in the population.

The major limitation in this method is the lack of confidence in interconnecting modes in the length-frequency distribution, as the peaks may be the outcome of different broods arising from different spawnings of the fish. Thus often two or more different broods can be connected as belonging to the same brood leading to unreliable results.

*c. Integrated Method:* To overcome these problems some new methods were proposed. Pauly (1980 and 1983) proposed the integrated method by combining the above two methods. A growth curve joining the majority of peaks is drawn directly upon the length-frequency distribution arranged sequentially in time or on to the sample repeated over and over along the time axis with the assumption that length growth in fish is fast in the early part of life and slows down later. Such a smooth curve is likely to represent the average growth of fishes in a population.

*d. ELEFAN Method:* Pauly and David (1981) developed computer software: Electronic Length Frequency Analysis called ELEFAN. The principle involved is to split the composite length-frequency into peaks and troughs and the best growth curve passing through maximum number of peaks avoiding troughs is selected using a goodness of fit, by a ratio of ESP/ASP (Estimated Sum of Points/Available Sum of Points). Peaks are assumed to represent individual cohorts. The procedure involves the following steps. Length-frequency samples are restructured for identifying 'peaks' and 'troughs' objectively and is allotted certain positive and negative points respectively. A growth curve is fitted for an arbitrary "seed" input value of $L\infty$ and K, starting from base of a certain peak by projecting forwards and backwards against time to meet all other samples of a sample-set arranged sequentially in time.

Whenever the curve hits a peak, (positive) or trough (negative) it scores points and the total sum of points is called ESP. Sum of scores from positive peaks in the curve is called ASP (Available). ESP/ASP = Rn is a measure of goodness of fit. The "seeded" values of $L\infty$ and K are increased or decreased until a growth curve with the highest vale of Rn is obtained. The corresponding "seed" values of L∞ and K are taken as final estimates of the Von Bertalanffy growth parameters.

Though a number of growth curves are developed, the Von Bertalanffy (1934) growth curve is used in fish populations because " it fits most of the observed data of fish growth, and can be incorporated readily into stock assessment models" (Gulland, 1983,p. 88). Hence the von Bertalanffy growth parameters are estimated using the ELEFAN method in the present work.

## MATERIALS AND METHODS

The data of five species of silverbellies *(Leiognathus splendens, L. brevirostris, Secutor insidiator, S. ruconius* and *Gazza minuta*), which account for 90% of the total landings of silverbellies in the region were utilised for estimating growth parameters. For this purpose, the length measurements were taken for 28550 specimens of *L. splendens,* 5474 of *L. brevirostris,* 13284 of *S. insidiator,* 1873 of *S. ruconius* and 3508 specimens of *Gazza minuta.* The length data were grouped into 5 mm class intervals. The data on length-frequency distribution of a sample were weighted to the estimated total catch of the species on the date of observation from each of the centres separately. Such estimated length-frequency distribution of all the sampling days were pooled and then weighted to the estimated total catch of the species from each of the centres. Thus the length-frequency distribution in the estimated catch of a species from each of the two selected landing centres was obtained. It is this data that formed the basic input for analysis of growth. Von Bertalanffy growth parameters were extracted making use of every year's data from each of the centres separately, the two years data from each centre separately, the data of the corresponding months from each of the centres pooled separately and the data of corresponding months from both the years from both the centres pooled. For this purpose the FiSAT package (Gayanilo *et al.,* 1988) was used.

The initial requirement for processing the length data using ELEFFAN is a guessed value of L∞. The maximum recorded length of each species was collected from the literature and the maximum lengths recorded in the present work were also taken into account. It is known (Gulland, 1983) that $L\infty$ represents the maximum length, a species can attain, it is also known that since the Von Bertalanffy growth curve represents an "average growth curve", the estimated $L\infty$ value can be less than maximum recorded length also. Hence different input values of $L\infty$ greater and smaller than the maximum recorded lengths were tried. After arriving at best possible estimates of $L\infty$ and K, the routine in the FiSAT package "output of results" was used to see whether the growth curve was passing through maximum number of modal lengths in the actual length frequency data. The analysis was carried out using different sets of data until a reasonably, satisfactory value of $L\infty$ and its compatible K was obtained. Finally the "best" estimates of $L\infty$ and K of all the estimates from different sets of data were taken as representing the growth curve of the species.

## RESULTS

The estimated values of $L\infty$ and K of the five species are shown in the table.

| S. No. | Name of the Species | $L\infty$ (mm) | K (Per Year) | $\phi$ |
|---|---|---|---|---|
| 1 | *Leiognathus splendens* | 154 | 0.52 | 4.09 |
| 2 | *Leiognathus brevirostris* | 140 | 0.86 | 4.23 |
| 3 | *Secutor insidiator* | 130 | 0.80 | 4.13 |
| 4 | *Secutor ruconius* | 92 | 1.19 | 4.01 |
| 5 | *Gazza minuta* | 160 | 1.70 | 4.64 |

The growth curves of the five species, *Leiognathus splendens, L. brevirostris, Secutor insidiator, S. ruconius* and *Gazza minuta* are shown in the restructured length-frequency data (ELEFAN) and are shown (Figures 48,49,50,51 & 52).

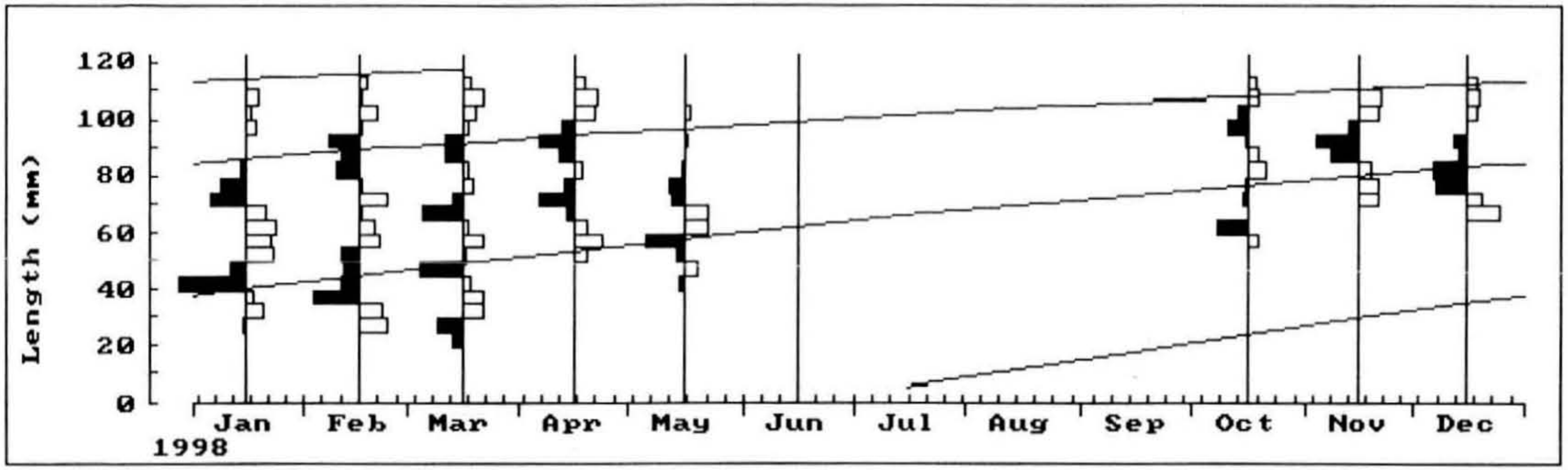



Figure. 48 Restructured length frequency data (ELEFAN I) and growth curves of *Leiognathus splendens*, Neendakara 1998: $L\infty$ = 154 mm, K = 0.52, SS = 1, SL = 39.5, Rn = 224

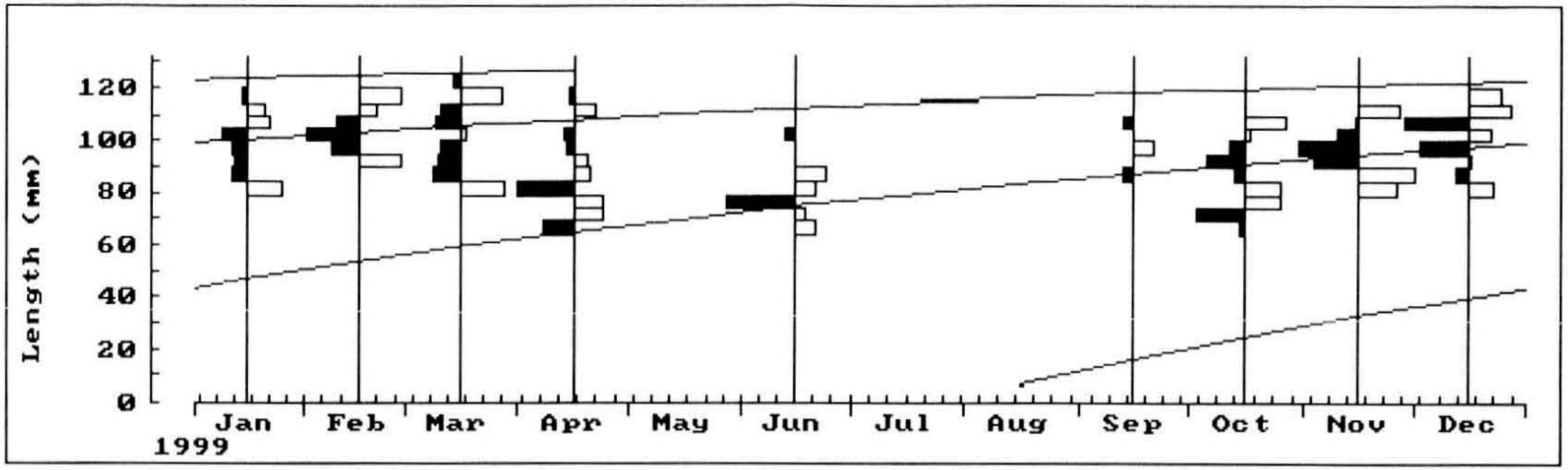



Figure. 49 Restructured length frequency data (ELEFAN I) and growth curves of *Leiognathus brevirostris*, Neendakara 1999: L∞ = 140 mm, K = 0.86, SS = 8, SL = 94.5, Rn = 385

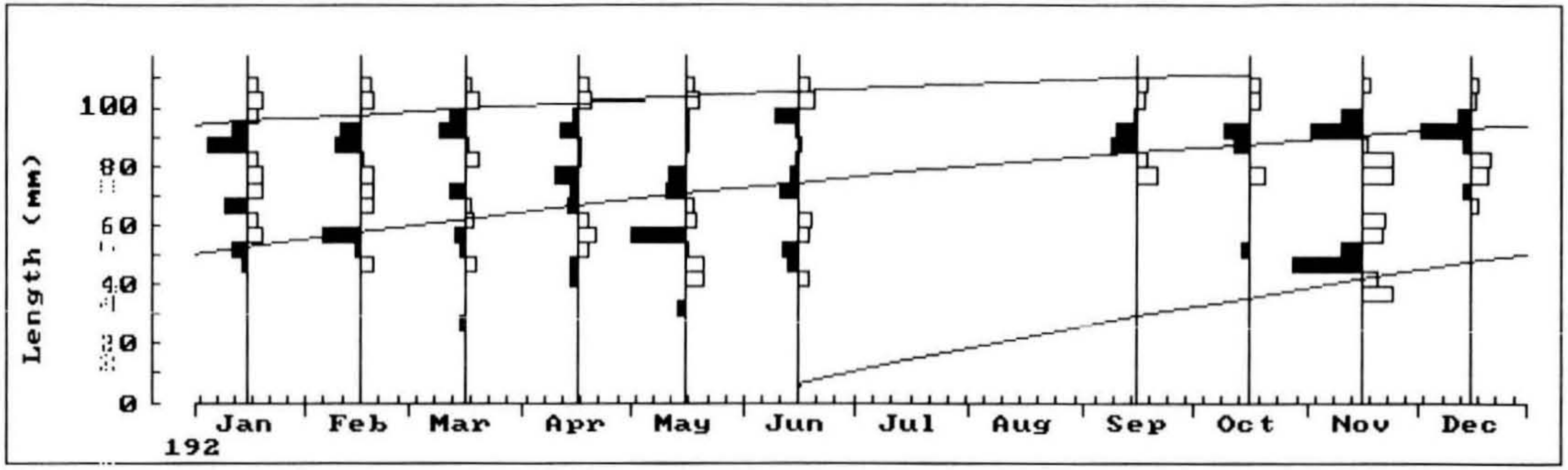



Figure. 50 Restructured length frequency data (ELEFAN I) and growth curves of *Secutor insidiator*, Cochin and Neendakara 1998 and 1999 pooled: $L_\infty$ = 130 mm, K = 0.80, SS = 7, SL = 84.5, Rn = 208

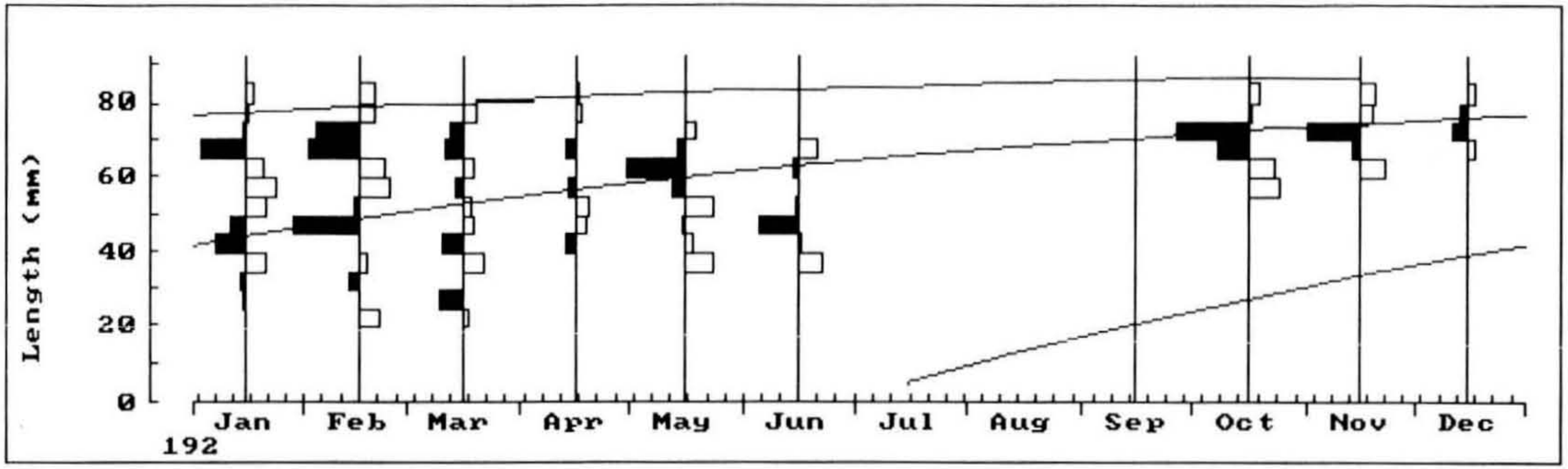



Figure. 51 Restructured length frequency data (ELEFAN I) and growth curves of *Sector ruconius*, Cochin and Neendakara 1998 and 1999 pooled: L∞ = 92 mm, K = 1.19, SS = 5, SL = 59.5, Rn = 313

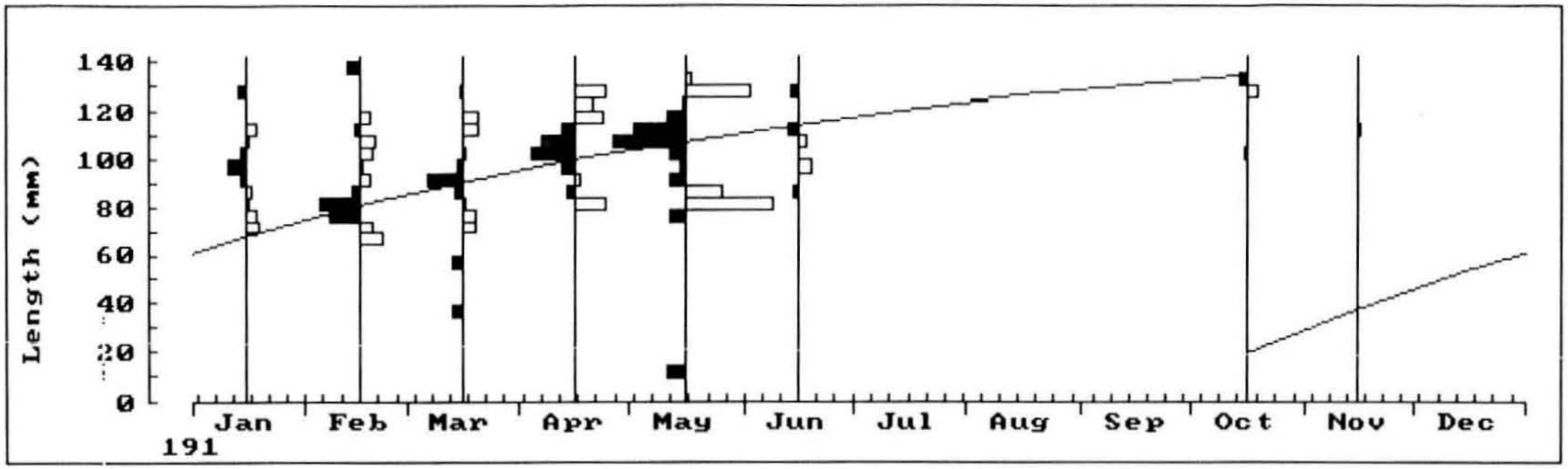



Figure. 52 Restructured length frequency data (ELEFAN I) and growth curves of *Gazza minuta*, Cochin 1998 and 1999: $L\infty$ = 160 mm, K = 1.70, SS = 4, SL = 99.5, Rn = 430

# LENGTH – WEIGHT RELATIONSHIP AND RELATIVE CONDITION FACTOR

The length-weight relationship in exploited fish stocks is determined for several purposes mainly, to express mathematically the relationship between the two variables to enable calculation of length if weight is known or vice versa and study the variation in weight of individual fish of a given length, from the expected weight, to indicate the condition and in the yield equation.

Besides, the regression coefficient of length-weight relationship is incorporated in the Beverton and Holt (1957) yield equation. Length-weight may be a character for the differentiation of small taxonomic units (Le Cren, 1951).

The length-weight relationship was calculated in *L. splendens, S. insidiator* and S. *ruconius* following Le Cren (1951) with the help of the equation Log W = Log a + b Log L, where W = total weight of the fish in grams and L is the total length in mm. The relative condition factor ($K_n$) was calculated as the ratio of observed and calculated weights for each length and the averages of different months in all the length groups and the averages of different length groups in all the months were considered.

The study is based on the length and weight data of 1703 specimens of *L. splendens*, 939 females, of the length range 72 mm -115 mm, and 663 males of the length range 71 mm - 109 mm, 988 specimens of *S. insidiator*, 637 females of the length range 63 mm - 108 mm and in 283 males, ranging in length from 80 mm to 106 mm total length and 150 specimens of *S. ruconius*, ranging in length from 38mm to 85mm collected during the period from January 1998 to December 1999.

The samples taken from the landing centre were brought to the laboratory and frozen. The length and weight measurements for these samples were measured in the next two to three days. The length is measured to nearest in mm and weight to nearest to 0.5 gram. As the relationship is curvilinear the relationship has been calculated after converting the data into logarithmic values, using the logarithmic form of the above exponential equation.

$$\log W = \log a + b \log L$$

The length-weight relationship of *L. splendens, S. insidiator* and *S.ruconius* are given (Figures 53,54&55)

The average $K_n$ values for each 5mm length groups were calculated and plotted against the respective length groups, for both *L. splendens and S. insidiator* and the results are shown (Figures 56&57).

Similarly the average condition factor for the different length groups pooled together for the different months from October 1998 – December 1999 for both the species mentioned above are displayed in (Figures 58&59).

**RESULTS**

The length weight relationship in *L. splendens* was estimated as

$W = 0.000006\ L^{3.163977}$ and

$\log W = \log 0.000006 + 3.163977 \log L$ and the $R^2$ value = 0.90

The length weight relationship in *S. insidiator* was obtained as

$W = 0.0000015\ L^{3.463096}$ and

$\log W = \log 0.0000015 + 3.463096 \log L$ and the $R^2$ value = 0.80

The length weight relationship in *S. ruconius* was obtained as

$W = 0.016212574\ L^{2.973626077}$ and

$\log W = \log 0.016212574 + 2.973626077 \log L$ and the $R^2$ value = 0.95

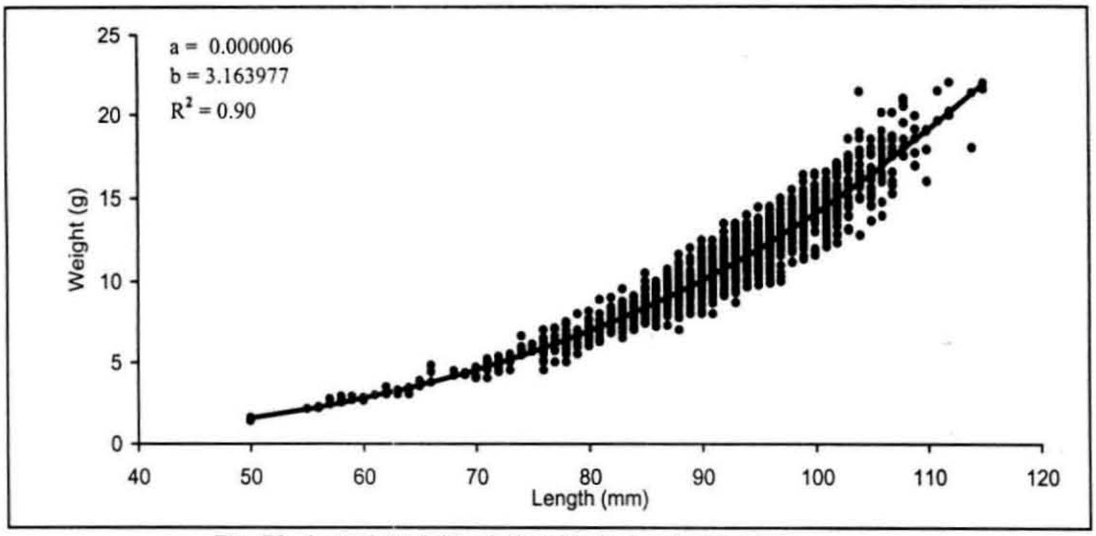



Fig. 53 Length-weight relationship in *L.splendens*

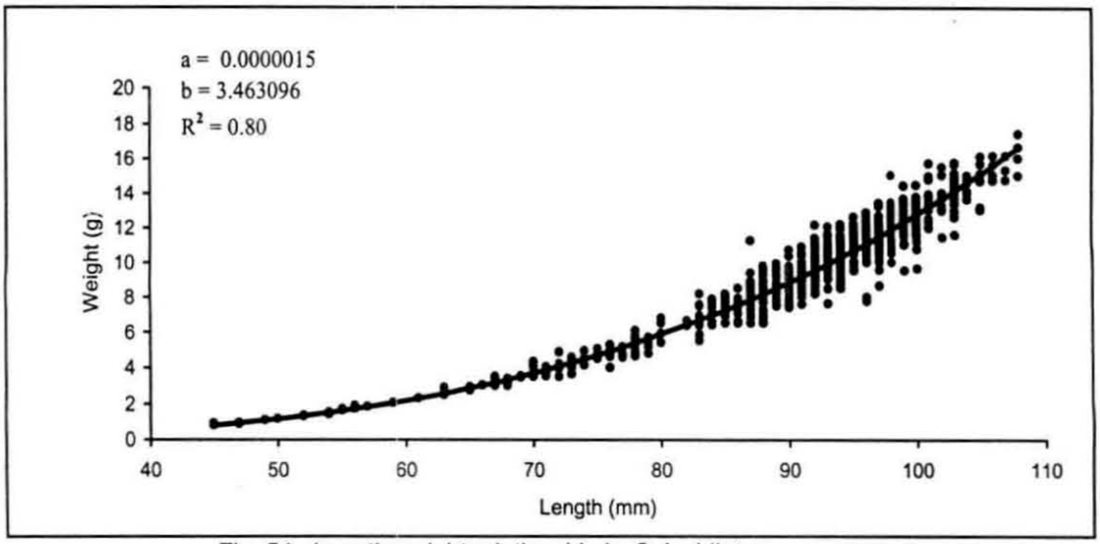



Fig. 54 Length-weight relationship in *S. insidiator*

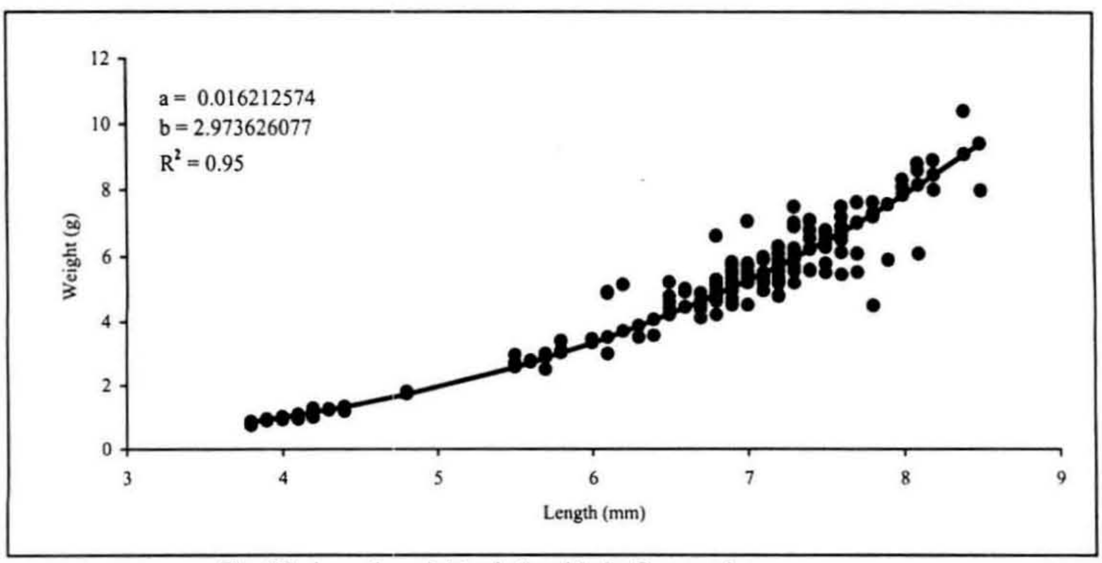



Fig. 55 Length-weight relationship in *S. ruconius*

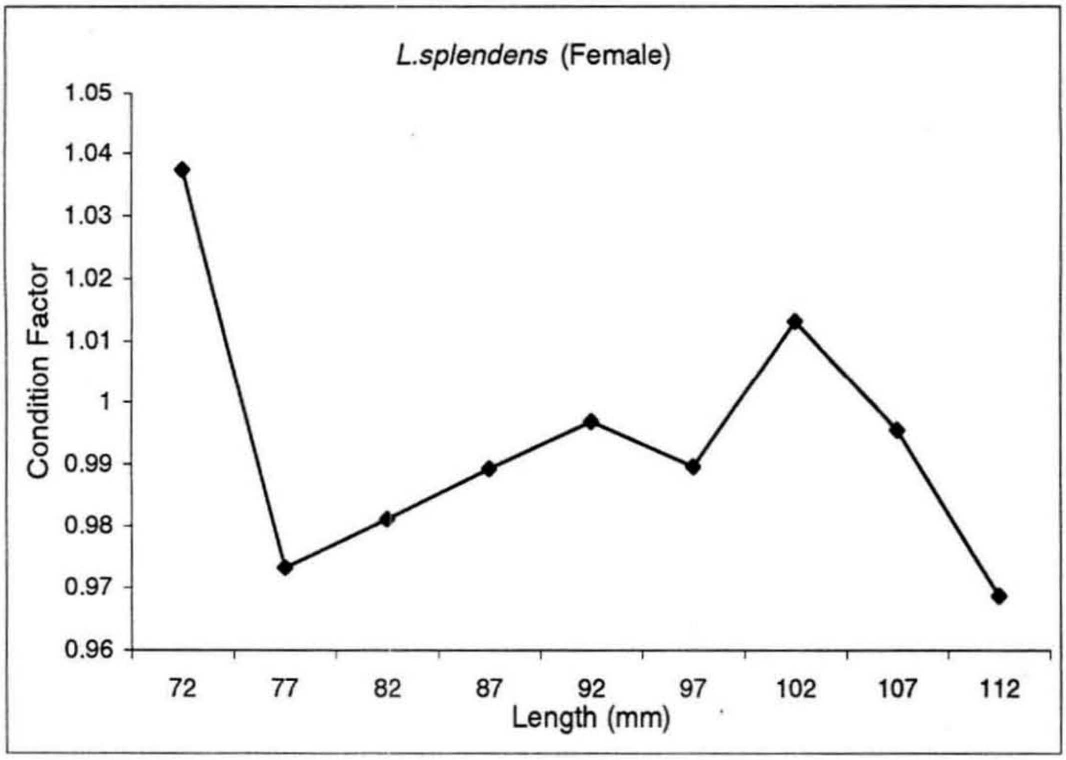



Fig. 56 Condition factor of females in dfifferent length ranges in *L.splendens*

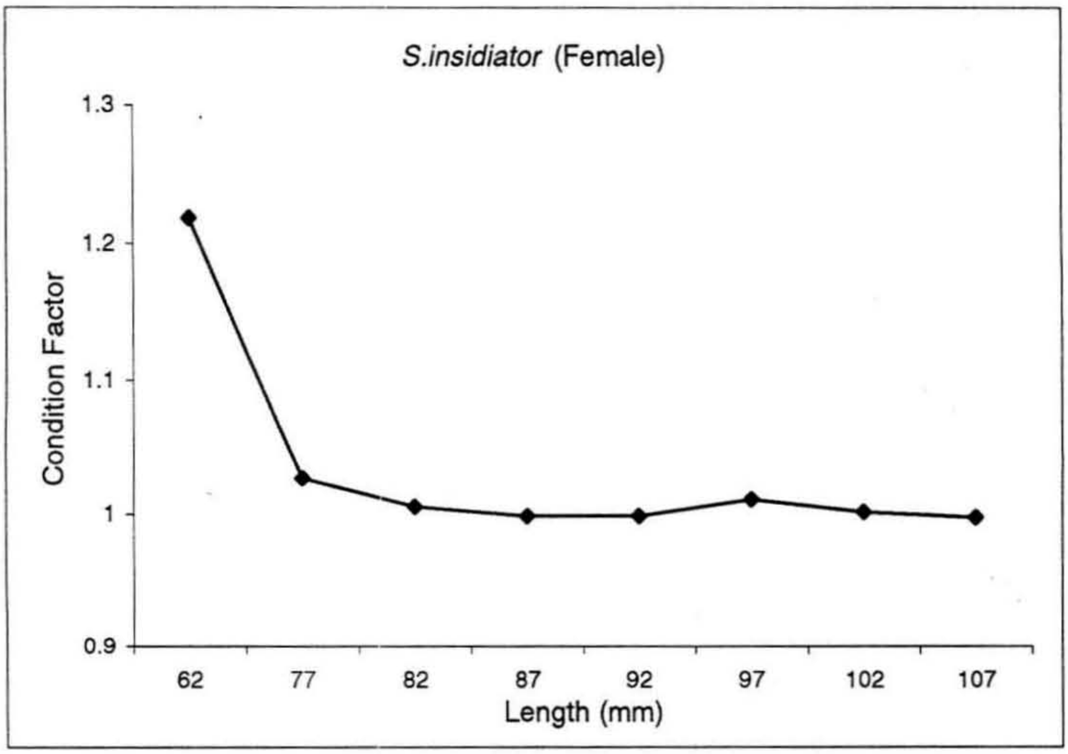



Fig.57 Condition Factor of females of different length ranges in *S.insidiator*

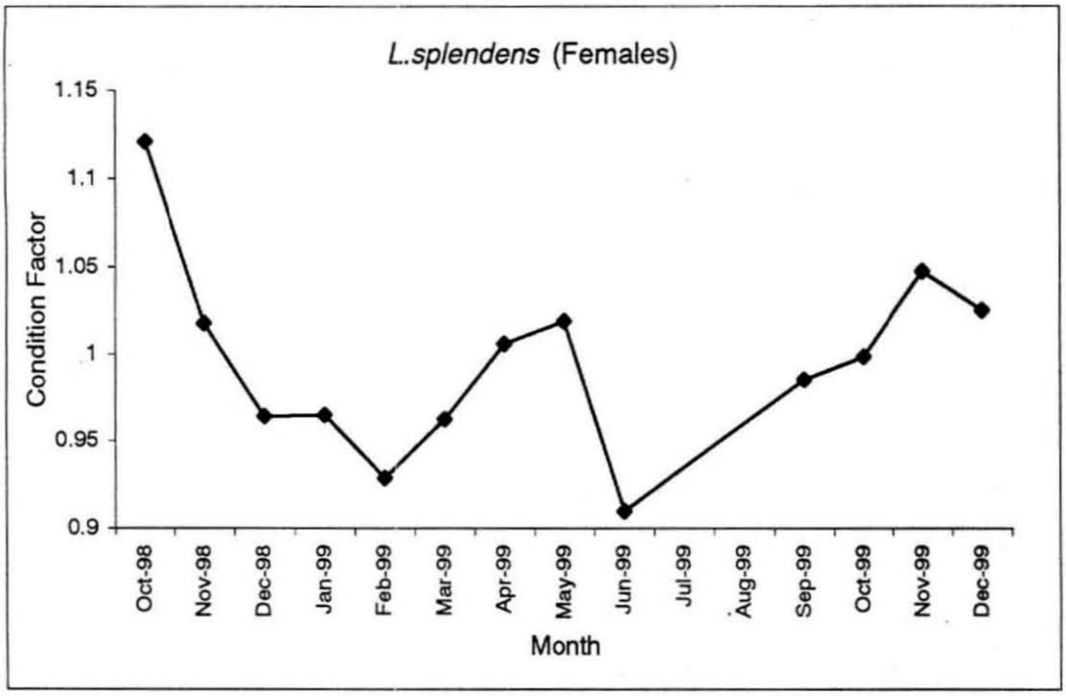



Fig. 58 Condition Factor of females in different months in *L.splendens*

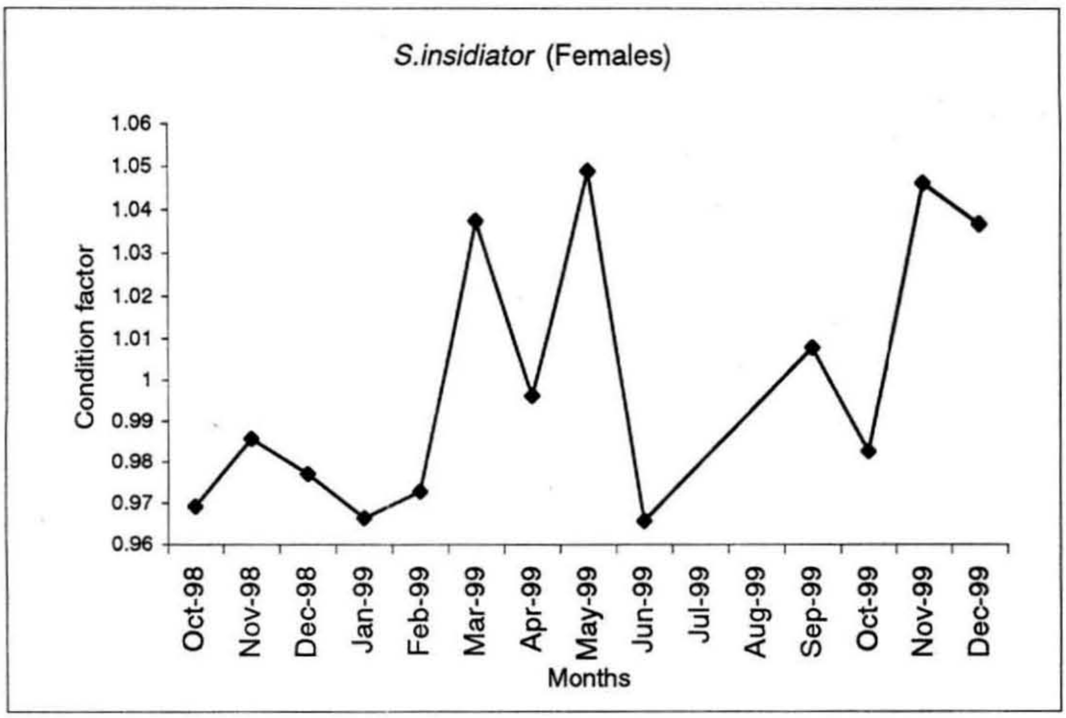



Fig. 59 Condition Factor of Females in different months in *S.insidiator*

The ($K_n$) value in *L. splendens* is lowest in the 75-79 mm length group, which correspond to the length at first maturity for the species, and shows a highest value in the 100- 104 mm length group.

In *S. insidiator* the $K_n$ value is highest in the 60-64 mm length group, and thereafter continues at a low level for all the length groups.

In *L. splendens* the condition factor does not show a correlation with the peak spawning period, no valid conclusions could be reached about its variation between months. In *S. insidiator*, the condition factor shows a high value in March 1999, corresponding with a peak occurrence of mature stages and thereafter shows an irregular pattern.

## DISCUSSION

As the Von Bertalanffy growth parameters are incorporated in the Beverton and Holt yield equation, the validity of the yield curve in any exploited species would depend upon the precision of the estimates of growth parameters used for the purpose. This could be best achieved by ensuring adequate samples of landings such that the samples from the landings could be taken as representing the population with respect to length frequency distribution. In the present study while large representative samples were ensured on all the dates of observations, the sampling strategy was such that the possible differences in the length composition between different boats landing on same day were also taken into account.

The ELEFAN method poses certain problems while attempting to extract the "best" growth curves. It has been observed during the analysis that several "best" estimates could be made on the basis of a single data set and it becomes increasingly difficult to really "choose" the most reliable set of growth parameters. On several occasions, high and maximum $R_n$ values were obtained at $L\infty$ values much higher than $L_{max}$ values known or much lower than the same whereas one would expect $L\infty$ values to be close to the $L_{max}$ values. As the $L_{max}$ values known in the literature were taken as seed values initially since the species has the potential to attain lengths close to the $L_{max}$, this problem was got over by selecting such growth curve which lead to estimation of $L\infty$ value close to the $L_{max}$ and the growth curves that pass through maximum number of positive peaks in the restructured length-frequency distribution . The validity of the growth curves chosen was also tested by fitting the growth curve on actual length frequency distribution through the available routine programme (output of results). The results obtained in the present work as well as by several authors on the species (Table 8) are comparable though such comparability is not a condition. As this is the first attempt from off Kerala coast there was no opportunity to compare similar values from this region. However in view of the sampling strategy and frequency followed and the care taken in extracting the most reliable values of $L\infty$ and K in this work, the estimated values can only be most reliable.

Studies on the length-weight relationship in silverbellies are few, concerning only very few workers. The important works are Arora (1952), on *L. splendens* off Rameswaram, Murty (1983), on *L. bindus* off Kakinada, James (1986), on *L. jonesi* off Palk Bay and Gulf of Mannar, Balan (1963) on *L. bindus* off Calicut, James and Badrudeen (1981) on *L. dussumeri* from Gulf of Mannar, Murty (1986b) on *L. bindus* along the West Bengal coast, Hameed Batcha and Badrudeen (1992), on *L. brevirostris* from Palk Bay and Jayabalan and Krishna Bhat (1997) on *L. splendens* and *G. minuta* off Parangipettai.

The length-weight relationship of silverbelly species calculated by earlier authors are furnished (Table. 9). In all the cases the authors analysed separately for sexes and tested the significance of the observed results by analysis of covariance and found that the differences were not statistically significant. The literature on fishes pertaining to the length-weight relationship of sexes shows that they are different only in instances where one sex attains a greater maximum length than the other; in other words there is differential growth rate between sexes in such species (Krishnamoorthi, 1971). In the present study the distribution of sexes did not reveal differences in their maximum length. Hence the relationship for the species is calculated.

Table 8: Estimated values of growth parameters, mortality rates, lengths and ages at entry and first capture of different species of silverbellies from the Indo-Pacific region

| Species | Area/Locality | Source | $L_\infty$ mm | K (per year | to (year) | $L_r$ | $t_r$ | $L_c$ | $t_c$ | Z | M | F | Ø |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | |
| *L.bindus* | Calicut, India | Pauly and David 1981 | 122 | 1.3 | - | - | - | - | - | - | - | - | 2.29 |
| | Java | Dwiponggo *et al.* 1986 | 125 | 1.38 | 0 | - | - | 50.3 | - | 8.84 | 2.83 | - | 2.33 |
| | Samar sea | Silvestre 1986 | 121 | 0.98 | 0 | - | - | - | - | 4.28 | 2.21 | 2.07 | 2.16 |
| | Visakhapatnam | Murty,*et al.*, 1992 | 151 | 0.95 | | | 0.087 | | 0.275 | 4.14 | 2.05 | 2.09 | 2.34 |
| | Kakinada | Murty,*et al.*, 1992 | 154 | 0.77 | | | 0.152 | | 0.412 | 5.26 | 1.78 | 3.48 | 2.26 |
| | Madras | Murty,*et al.*, 1992 | 153 | 0.9 | | | 0.172 | | 1.022 | 5.22 | 1.98 | 3.24 | 2.32 |
| | Visakhapatnam | Murty,*et al.*, 1992 | 163 | 0.95 | | | 0.08 | | 0.257 | 4.72 | 2.01 | 2.61 | 2.4 |
| | Kakinada | Murty,*et al.*, 1992 | 165 | 0.7 | | | 0.155 | | 0.412 | 5.43 | 1.64 | 3.79 | 2.28 |
| | Madras | Murty,*et al.*, 1992 | 167 | 0.96 | | | 0.147 | | 0.814 | 7.44 | 2.01 | 5.43 | 2.43 |
| | Kakinada, India | Murty,*et al.*, 1992 | 158.4 | 0.58 | -0.024 | 17 | 0.18 | 57 | 0.75 | 5.2 | 1.5 | 3.7 | 2.16 |
| *L. jonesi* | Mandapam, India | Venkataraman *et al.* 1981 | 161.2 | 0.528 | 0.111 | - | - | 48 | 0.56 | 3.2 | 2.28 | 0.92 | 2.14 |
| | Mandapam, India | Karthikeyan *et al.* 1989 | 146.62 | 0.917 | 0 | 15 | - | - | - | 5.26 | 1.25 | 4.01 | 2.29 |
| | Rameswaram | Murty,*et al.*, 1992 | 155 | 0.7 | | | 0.33 | | 1.076 | 5.36 | 1.67 | 3.69 | 2.23 |
| | Rameswaram | Murty,*et al.*, 1992 | 160 | 0.6 | | | 0.372 | | 0.961 | 4.95 | 1.5 | 3.45 | 2.19 |
| *L. splendens* | Porto Novo, India | Jayabalan 1988a | 170 | 0.3259 | -1.4159 | - | - | - | - | - | - | - | 1.97 |
| | Samar sea | Silvestre 1986 | 131 | 0.9 | 0 | - | - | - | - | 3.13 | 2.02 | 1.11 | 2.19 |
| | Java | Dwiponggo *et al.* 1986 | 145 | 1.25 | 0 | - | - | 96.5 | - | 4.64 | 2.55 | 2.09 | 2.42 |
| | " | " | 169 | 1.1 | 0 | - | - | 62.3 | - | 4 | 2.25 | 1.75 | 2.5 |
| | " | " | 167 | 0.9 | 0 | - | - | 62.3 | - | 3.27 | 1.98 | 1.25 | 2.4 |
| *L. equulus* | Samar sea | Silvestre 1986 | 240 | 0.56 | 0 | - | - | - | - | 2.2 | 1.26 | 0.94 | 2.51 |
| | Java | Dwiponggo *et al.* 1986 | 215 | 1.5 | 0 | - | - | 134 | - | 5.68 | 2.5 | 3.1 | 2.84 |
| *L. elongatus* | Malaysia | Chan and Liew 1986 | 135 | 0.8 | 0 | - | - | - | - | 3.1 | 1.8 | 1.3 | 2.16 |
| *L. leuciscus* | Samar sea | Silvestre 1986 | 137 | 0.93 | 0 | - | - | - | - | 3.86 | 2.12 | 1.74 | 2.24 |
| | Java | Dwiponggo *et al.* 1986 | 135 | 1.83 | 0 | - | - | 47.6 | - | 6.15 | 3.31 | 2.84 | 2.52 |
| *L. brevirostris* | Java | Dwiponggo *et al.* 1986 | 120 | 0.95 | 0 | - | - | 71 | - | 2.79 | 2.2 | 0.59 | 2.14 |
| *L. dussumieri* | Pamban | Murty, 1992 | 162 | 1.2 | | | 0.25 | | 0.63 | 6.7 | 2.35 | 4.35 | 2.5 |
| | Pamban | Murty, 1992 | 175 | 0.8 | | | 0.343 | | 0.851 | 5.46 | 1.76 | 3.7 | 2.39 |
| *S.insidiator* | Kakinada, India | Murty,1991 | 123 | 1.2 | -0.01 | 27 | 0.2 | 80 | 0.86 | 6.1 | 2.6 | 3.5 | 2.26 |
| | Visakhapatnam | Murty, 1992 | 120 | 1.2 | | | 0.258 | | 1.052 | 4.88 | 2.55 | 2.33 | 2.24 |
| | Kakinada | Murty, 1992 | 125 | 1.06 | | | 0.279 | | 1.1 | 4.69 | 2.33 | 2.36 | 2.22 |
| | Madras | Murty, 1992 | 125.5 | 1.22 | | | 0.334 | | 1.011 | 5.67 | 2.55 | 3.12 | 2.28 |
| | Visakhapatnam | Murty, 1992 | 130 | 0.85 | | | 0.332 | | 1.31 | 5.28 | 1.99 | 3.29 | 2.16 |
| | Kakinada | Murty, 1992 | 130 | 0.85 | | | 0.332 | | 1.291 | 4.36 | 1.99 | 2.37 | 2.16 |
| | Madras | Murty, 1992 | 138 | 1.3 | | | 0.279 | | 0.81 | 8.72 | 2.59 | 6.13 | 2.39 |
| *S. ruconius* | Java | Dwiponggo *et al.* 1986 | 90 | 2.2 | 0 | - | - | 36 | - | 8.91 | 4.22 | 4.69 | 2.25 |
| | Java | do | 83 | 1.45 | 0 | - | - | 49 | - | 8.86 | 3.29 | 5.57 | 2 |
| *G.minuta* | Porto Novo, India | | 160 | 0.8649 | -0.2316 | - | - | - | - | - | - | - | 2.34 |

*Note:* All lengths in mm, weights in grams and ages in years. The Z values are those obtained by length-converted catch curve method.

Table.9 Length weight relationship of different silverbelly species from India

| Length weight relaionship | *Species* | Author | Localiy | Year | a | b |
|---|---|---|---|---|---|---|
| Log W=-4.8233+3.2 Log L | *L.splendens* | Arora,H.L | Rameshwaram | 1952 | -4.8233 | 3.2 |
| Log W=-4.7850+2.9591L | *L.dussumieri* | James & Badrudeen | Gulf of Mannar | 1981 | -4.785 | 2.9591 |
| Log W=-4.77709+2.96182Log L | *L.bindus* | Murty,V.S.R. | Kakinada | 1983 | -4.77709 | 2.96182 |
| Log W=-5.38217+3.28637 log L | *L.bindus* | Murty,V.S.R. | West Bengal | 1986 | -5.38217 | 3.28637 |
| Log W=-5.2021+3.2167Log L | *L.jonesi* | James, P.S.B.R. | Madapam | 1986 | -5.2021 | 3.2167 |
| Log W=-4.47690+2.887Log L | *L.jonesi* | Karthikeyan *etal.,* | Rameshwaram | 1989 | -4.47690 | 2.887 |
| Log W= -5.73713+3.43654 Log L | *S.insidiator* | Murty,V.S.R. | Kakinada | 1990 | -5.73713 | 3.43654 |
| Log W= -4.8512+3.004 Log L | *L.brevirostris* | Hameed Batcha &Badrudeen | Palk Bay | 1992 | -4.8512 | 3.004 |

# Chapter IV

# Population Dynamics

# POPULATION DYNAMICS

## INTRODUCTION

Fisheries are based on stocks of wild populations inhabiting the sea in their natural environments. The success of capture fisheries depends on the state of these stocks. The purpose of study of fish population dynamics of exploited stocks is to offer scientific advice on the possible range of options for rational exploitation. By increasing the fishing effort, the yield can be increased to a certain level, but further increase in exploitation levels leads to reduction in the yield and if the effort is still further increased regardless of the reduction in total catch and catch rates, the stock under exploitation may collapse and the fishing industry faces the problem of rehabilitation. Such a situation would arise if proper scientific advice on the maximum possible effort and safe gear and mesh levels that could be deployed to exploit the resources of a stock/stocks in a given geographic area, was not made available and even if made available not implemented. Hence, the exploited stocks need to be maintained carefully and scientific advice rendered to the government and industry on the range of measures required to ensure maximum economic and sustainable yield.

The theory of population dynamics was developed through the works of Baranov (1918), Russell (1931), Graham (1935,1939), Ricker (1954), Nikolsky (1953), Schaefer (1954), Beverton and Holt (1957), Gulland (1966 and 1969) etc. Recently the subject has made much progress through the works of Caddy (1980), Pope (1980), Jones (1984), Garcia (1985) and others.

The studies on population dynamics of Indian silverbellies are those of Venkatarman *et. al.* (1981) on *Leiognathus jonesi,* Murty (1986a, 1986b, 1990) on *L.bindus* and *S.insidiator,* Kartikeyan *et al.* (1989) on *L. jonesi,* and Murty *et al.*, (1992) on four species along the Andhra Pradesh and Tamilnadu coasts.

## Materials and Methods

*1. Estimation of mortality rates:* The rate of total instantaneous mortality (Z) was estimated by length –converted catch curve of Pauly, (1983) using the total annual length-frequency distribution of catch from the two landing centres pooled. The natural mortality rate (M) was estimated using the equation of Pauly (1980). For this purpose the temperature value in the fishing grounds was taken as 27° C following Suseelan and Rajan (1989). The value of rate of fishing mortality (F) was derived from Z and M.

*2. Estimation of yield per recruit:* This was done by using the Beverton and Holt (1957) yield equation. The smallest length in the catch of each species over the two year period was taken as length at recruitment. The length at first capture was taken as equal to the length at recruitment. The value of $W\infty$ derived using the value of $L\infty$ and the estimated length-weight relationship. In the cases of *Leiognathus brevirostris* and *Gazza minuta* the values of length – weight relationship has not been calculated in the present work. Hence, the values given by Hameed Batcha and Badrudeen (1992), and Jayabalan and Krishna Bhat (1997) were taken.

*3. Estimation of recruitment pattern:* This has been estimated using the FiSAT package.

*4. Estimation of yield and mixed fishery assessments:* As the yield per recruit of different species cannot be pooled, the following procedure was adopted to make mixed fisheries assessment in respect of the five species studied.

a. The present F values in each species were decreased and increased by the same factor (as 10%, 20%, 30%, ....120%...200% of present F).

b. Using the resultant F values, the present $t_c$ and other required parameters, the Beverton – Holt (1957) yield per recruit analysis was made. This resulted in yield-effort curve for each species at different levels of the present F (F-Factor or percent of present F).

c. Taking the value of yield per recruit ($Y_w/R$) at the current $t_c$ and F and the value of annual average yield (1998 –99) of each of the species, the recruitment in numbers [R = Y/(Y/R)] was estimated.

d. The Yw/R at each F in each species as obtained at b above was weighted by the value of R (obtained at c above) to obtain values of yield in weight at different F (i.e. percentages of present F) values.

e. The values of yield at different F values (i.e. percentage of present F) of the five species were pooled to get yield-effort curve for five species together.

In the case of yield mesh curves ($Y_w/R$ as a function of age at first capture) the procedure similar to the above, was followed.

**Results**

The estimated values of total and natural mortality rates of all the five species are furnished (Table 10) and (Figures 60,61,62,63&64). The yield per recruit as a function of fishing mortality rate (under the current $t_c$) shows that the present fishing mortality rate is much beyond the level at which maximum yield per recruit is obtained in *L. splendens, S. insidiator, S. ruconius and G.minuta*, but, in the case of *L. brevirostris*, these are close to each other (Figures 65,66,67,68&69). Thus, in all the species considered here, the fishing pressure is higher than the level at which greater yield per recruit could be obtained (Figures 70,71,72,73&74).

The yield per recruit as a function of age at first capture (under the current F) shows that the present age at first capture in all the five species is far less than the level at which maximum $Y_w/R$ could be obtained.

The yield estimated as a function of fishing mortality rate expressed at percent of the present shows (Figures 75,76,77,78&79), that maximum yield could be obtained at around 20% of the present fishing mortality rate in *L. splendens,* at the current level in *L. brevirostris*, at around 20% level in *S. insidiator*, about 60% level in *S.ruconius*, about 30% level in *G.minuta*. In all the five species together, the maximum equilibrium yield of around 8000 t could be harvested at around 20% level of the present fishing mortality (Figure 80) In the case of yield as a function of age at first capture, there is scope for

Table.10 Estimated values of growth parameters, mortality rates, lengths and ages at entry and first capture of different species of silverbellies as used in the present study ($\phi$ values are also shown)

| Species | L max (mm) | a | b | $L_\infty$ mm | K (per year) | Z | M | F | $t_c$ | $\phi$ | M/K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Leiognathus splendens* | 140 | 0.000006 | 3.16398 | 154 | 0.52 | 6.55 | 1.38 | 5.42 | 0.06 | 4.09 | 2.65 |
| *L. brevirostris* | 135 | 0.000014 | 3.004 | 140 | 0.86 | 7.59 | 1.97 | 5.26 | 0.65 | 4.23 | 2.29 |
| *Secutor insidiator* | 120 | 0.0000015 | 3.46309 | 130 | 0.8 | 7.16 | 1.91 | 5.25 | 0.27 | 4.03 | 2.38 |
| *S. ruconius* | 98 | 0.0162126 | 2.97363 | 92 | 1.19 | 6.14 | 2.73 | 3.43 | 0.21 | 4.01 | 2.29 |
| *Gazza minuta* | 180 | 0.000012 | 3.0526 | 160 | 1.7 | 8.91 | 2.96 | 5.95 | 0.03 | 4.64 | 1.74 |

*Note:* All lengths in mm, weights in grams and ages in years. The Z values are those obtained by length-converted catch curve method; a and b are constants of length-weight relationship.

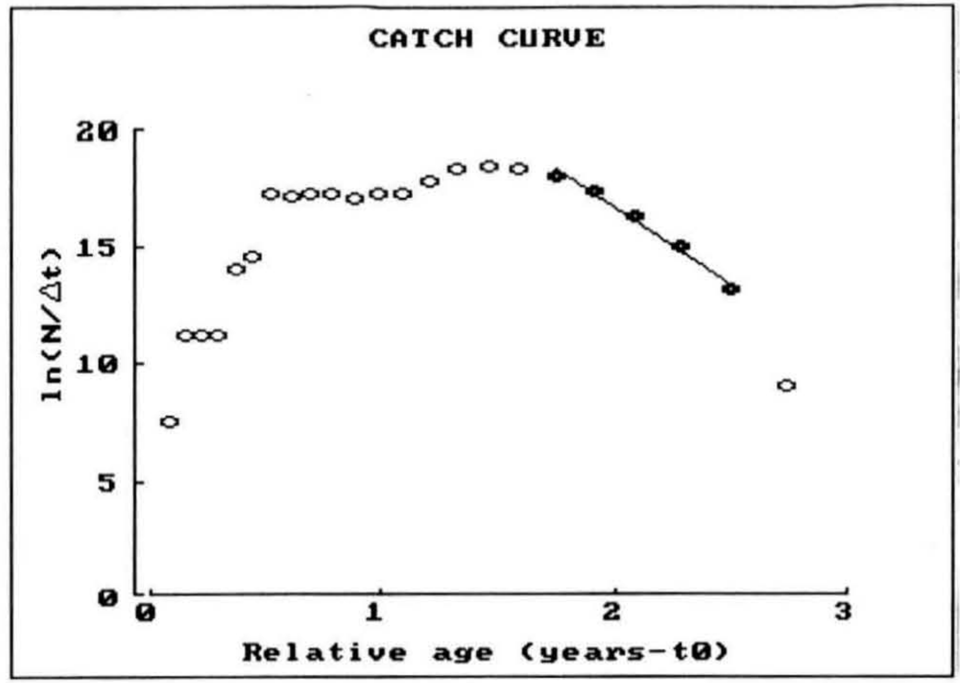



Figure. 60 Length-converted catch curve of *Leiognathus splendens* (data of 1998 and 1999 from Cochin and Neendakara pooled)

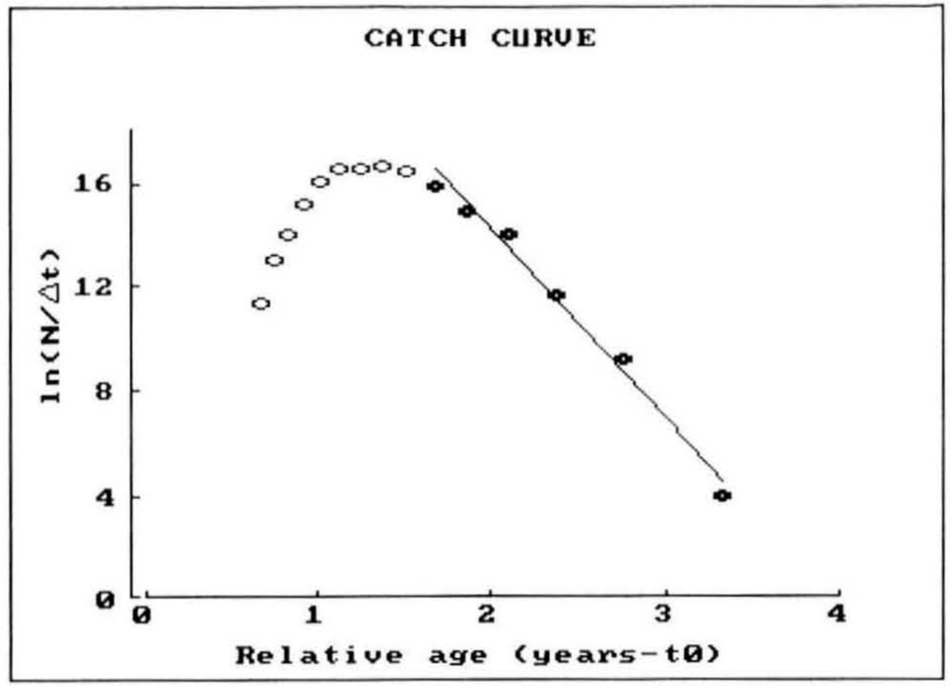



Figure. 61 Length-converted catch curve of *Leiognathus brevirostris* (data of 1998 and 1999 from Cochin and Neendakara pooled)

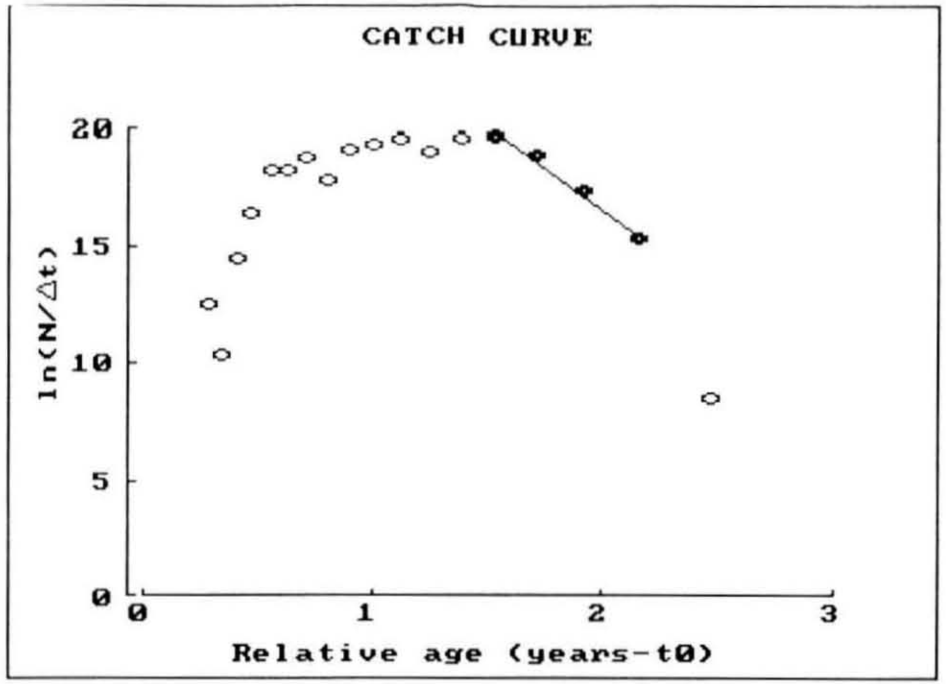



Figure. 62 Length-converted catch curve of *Secutor insidiator* (data of 1998 and 1999 from Cochin and Neendakara pooled)

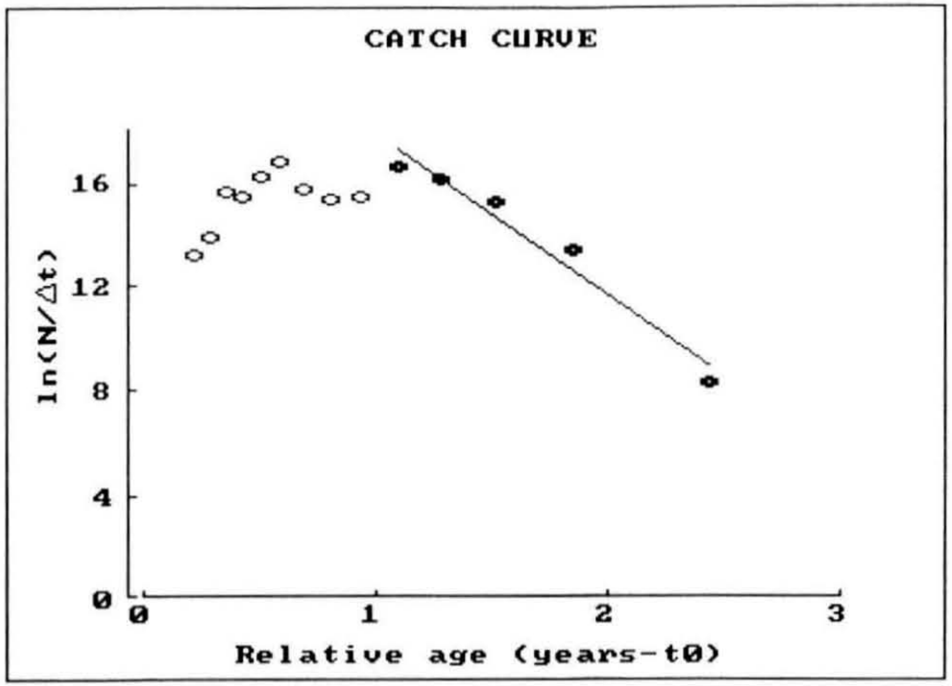



Figure. 63 Length-converted catch curve of *Sector ruconius* (data of 1998 and 1999 from Cochin and Neendakara pooled)

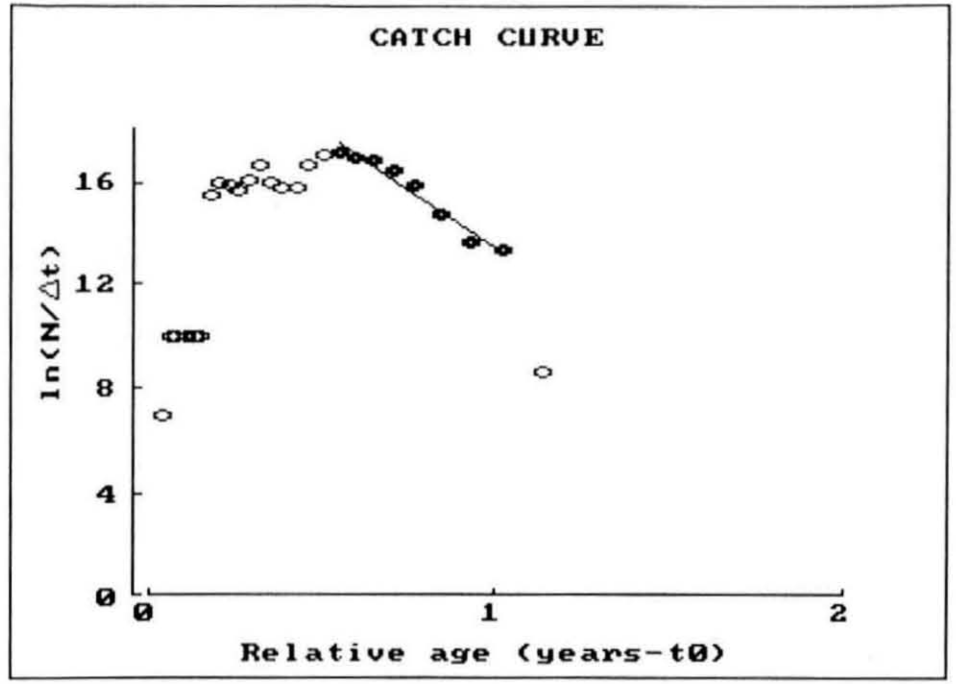
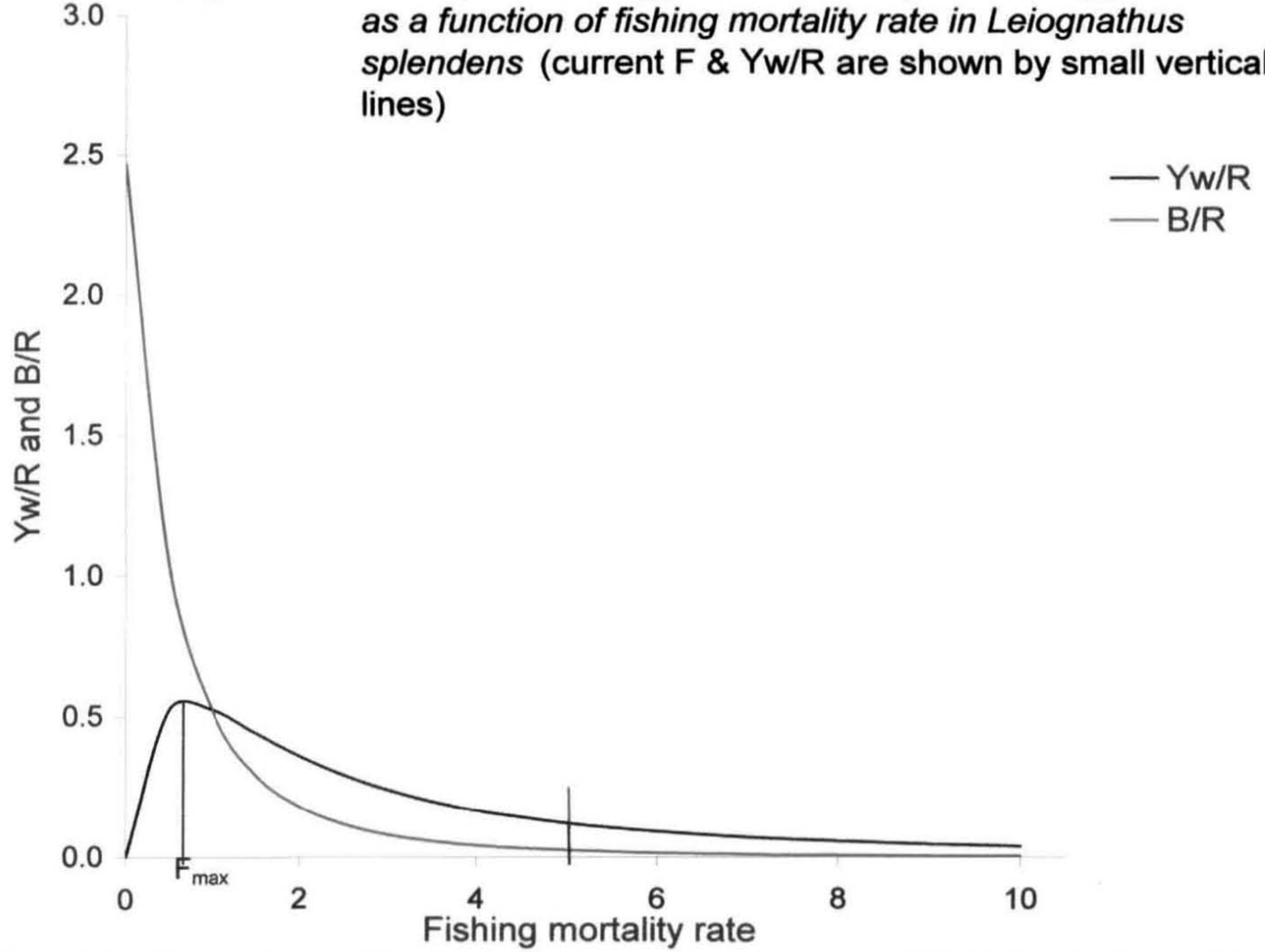



Figure. 64 Length-converted catch curve of *Gazza minuta* (data of 1998 and 1999 from Cochin and Neendakara pooled)

Figure: 65 Yield per recruit (g) and biomass per recruit (g) *as a function of fishing mortality rate in Leiognathus splendens* (current F & Yw/R are shown by small vertical lines)



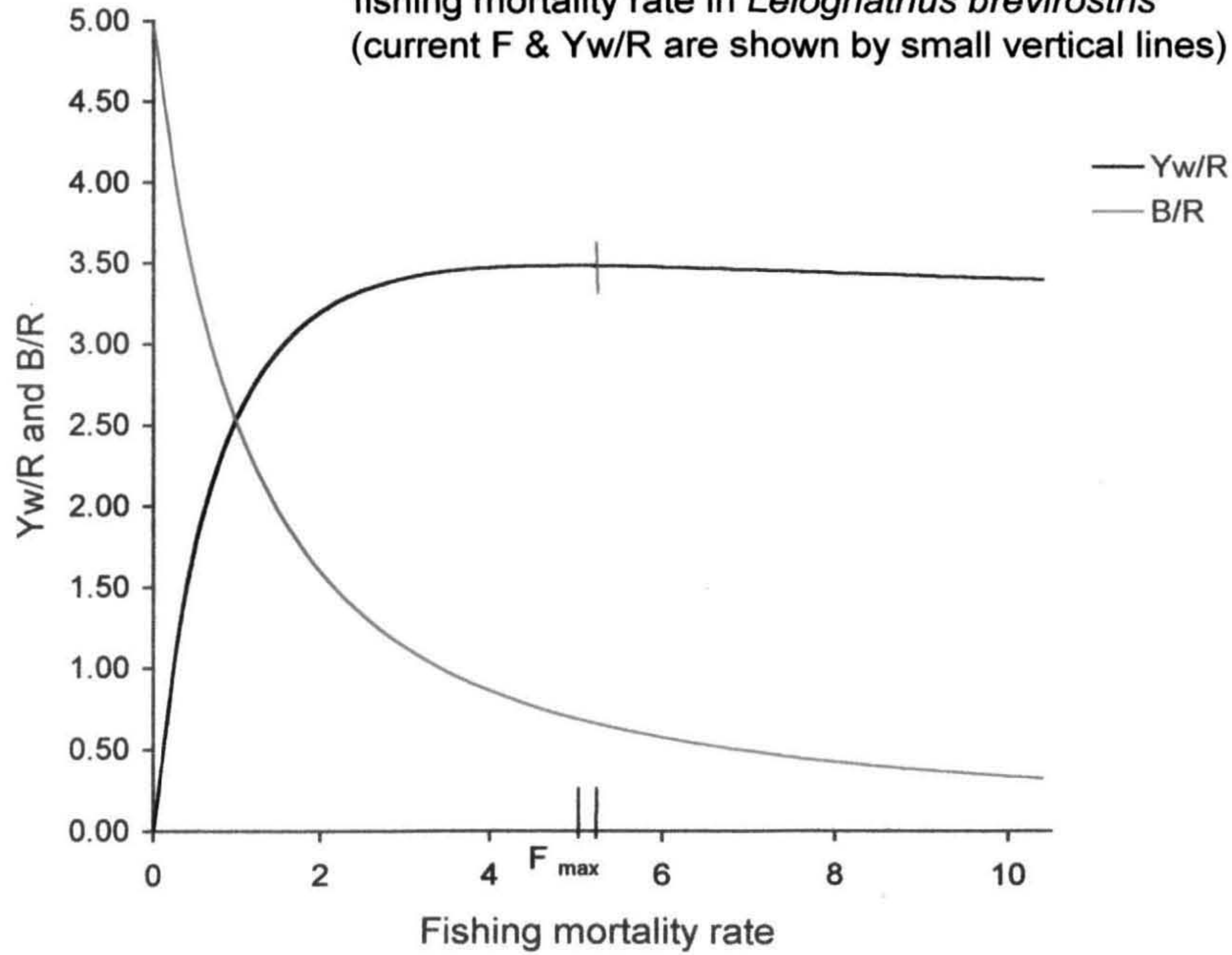



Figure: 66 Yield per recruit (g) and biomass per recruit(g) as a function of fishing mortality rate in *Leiognathus brevirostris* (current F & Yw/R are shown by small vertical lines)

Figure: 67 Yield per recruit (g) and biomass per recruit (g) as a function of fishing mortality rate in *Secutor insidiator* (current F & Yw/R are shown by small vertical lines)

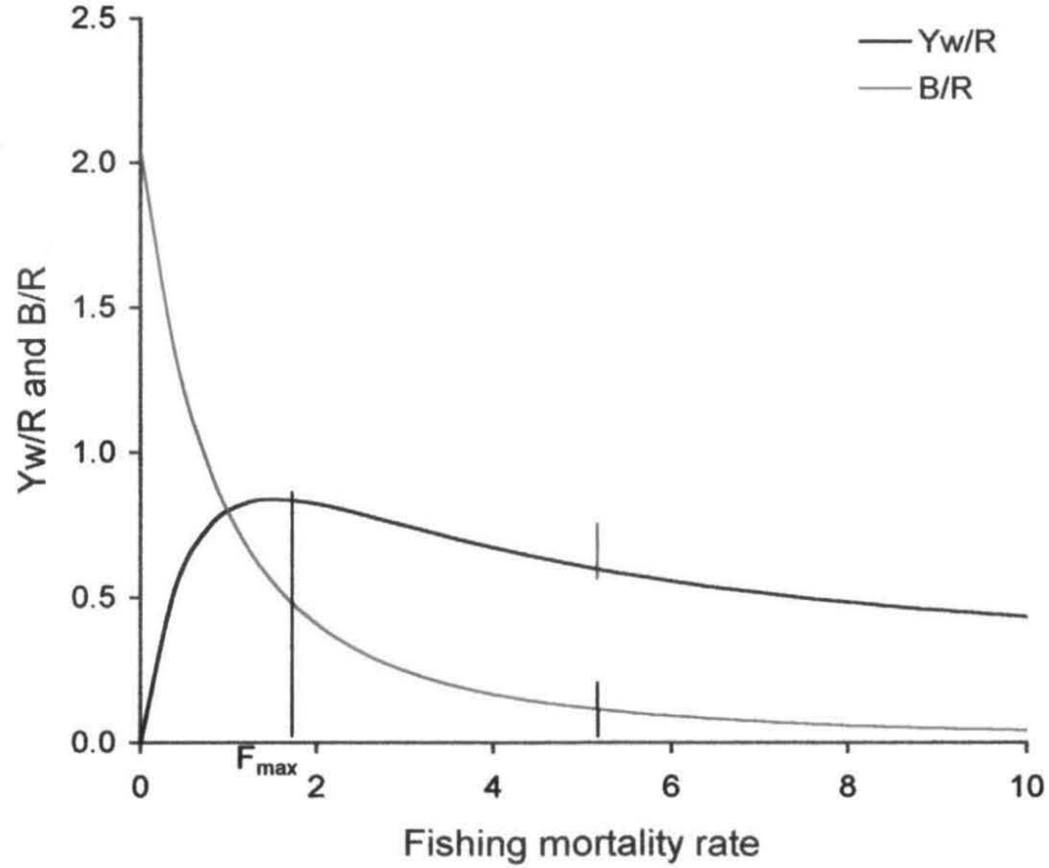


Figure: 68 Yield per recruit (g) and biomass per recruit (g) as a function of fishing mortality rate in *Secutor ruconius* (current F & Yw/R are shown by small vertical lines)

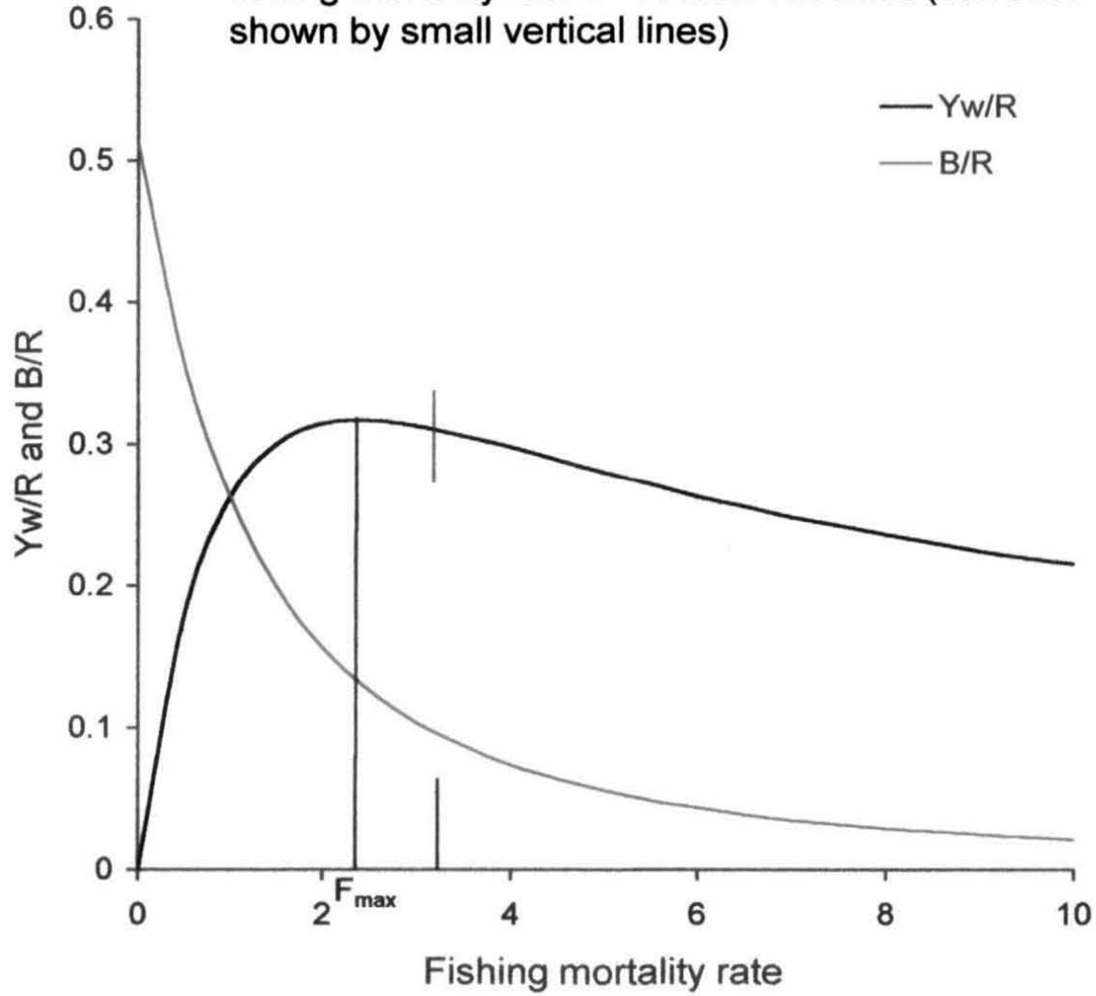
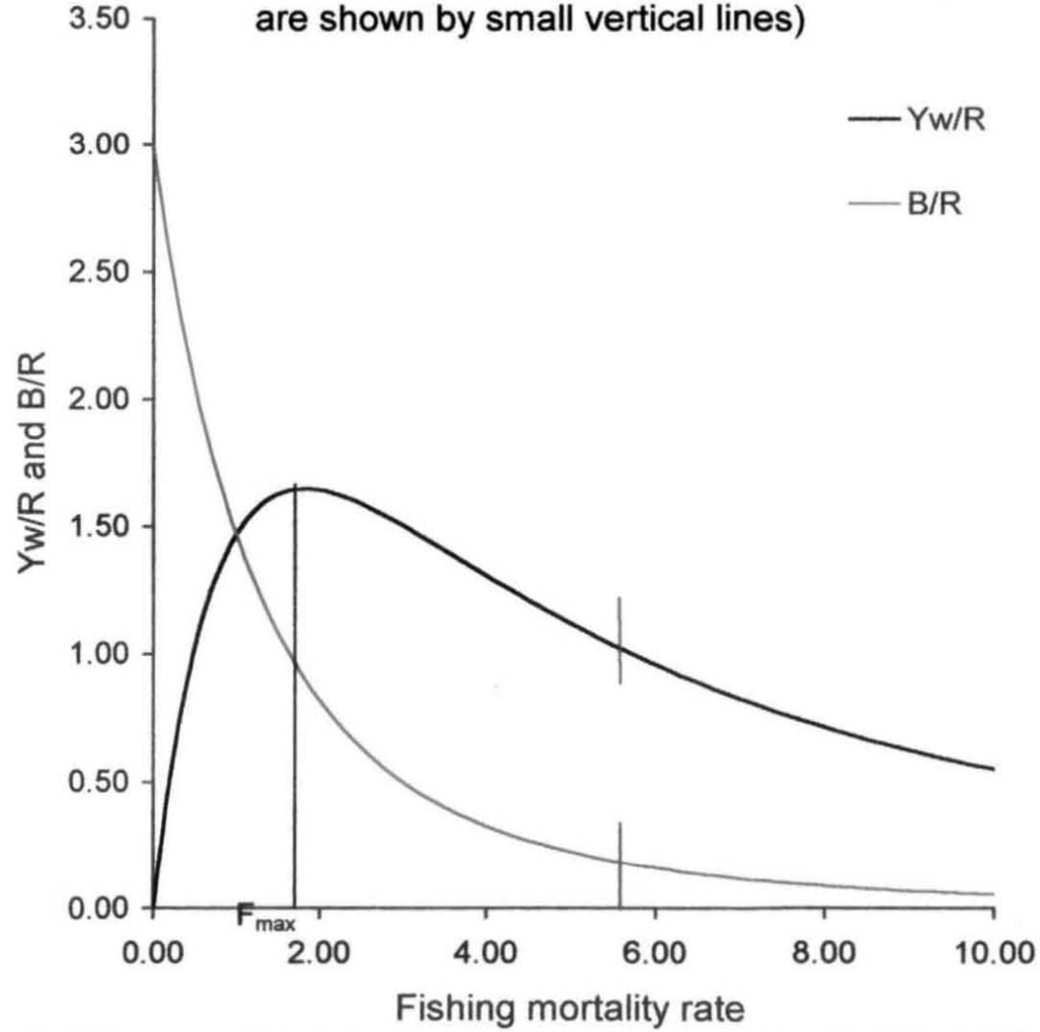


Figure: 69 Yield per recruit (g) and biomass per recruit (g) as a function of fishing mortality rate in *Gazza minuta* (current F & Yw/R are shown by small vertical lines)



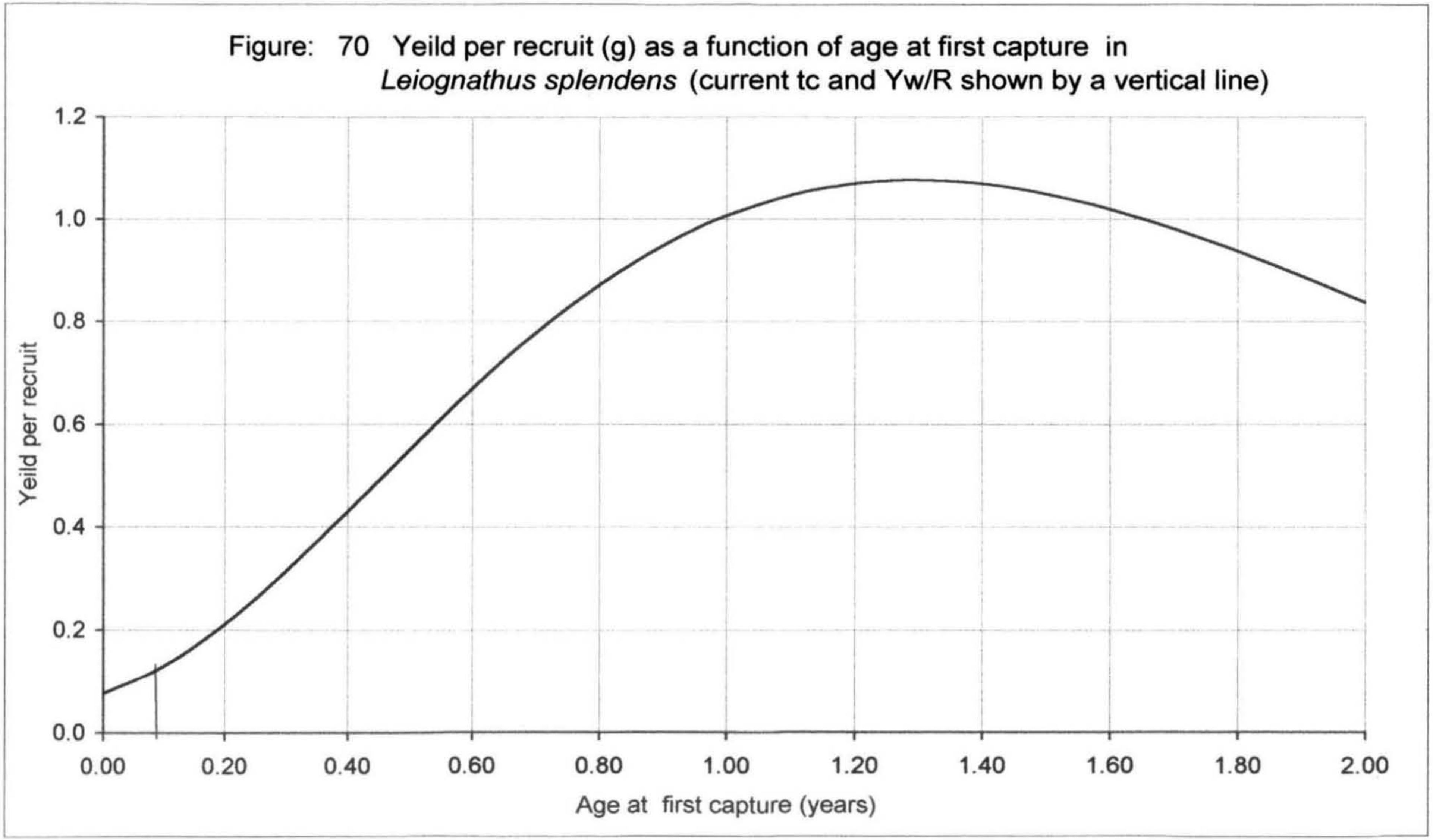


Figure: 70 Yeild per recruit (g) as a function of age at first capture in
*Leiognathus splendens* (current tc and Yw/R shown by a vertical line)
Yeild per recruit
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
Age at first capture (years)

Figure: 71 Yeild per recruit (g) as a function of age at first capture in *Leiognathus brevirostris* (current tc and Yw/R shown by a vertical line)

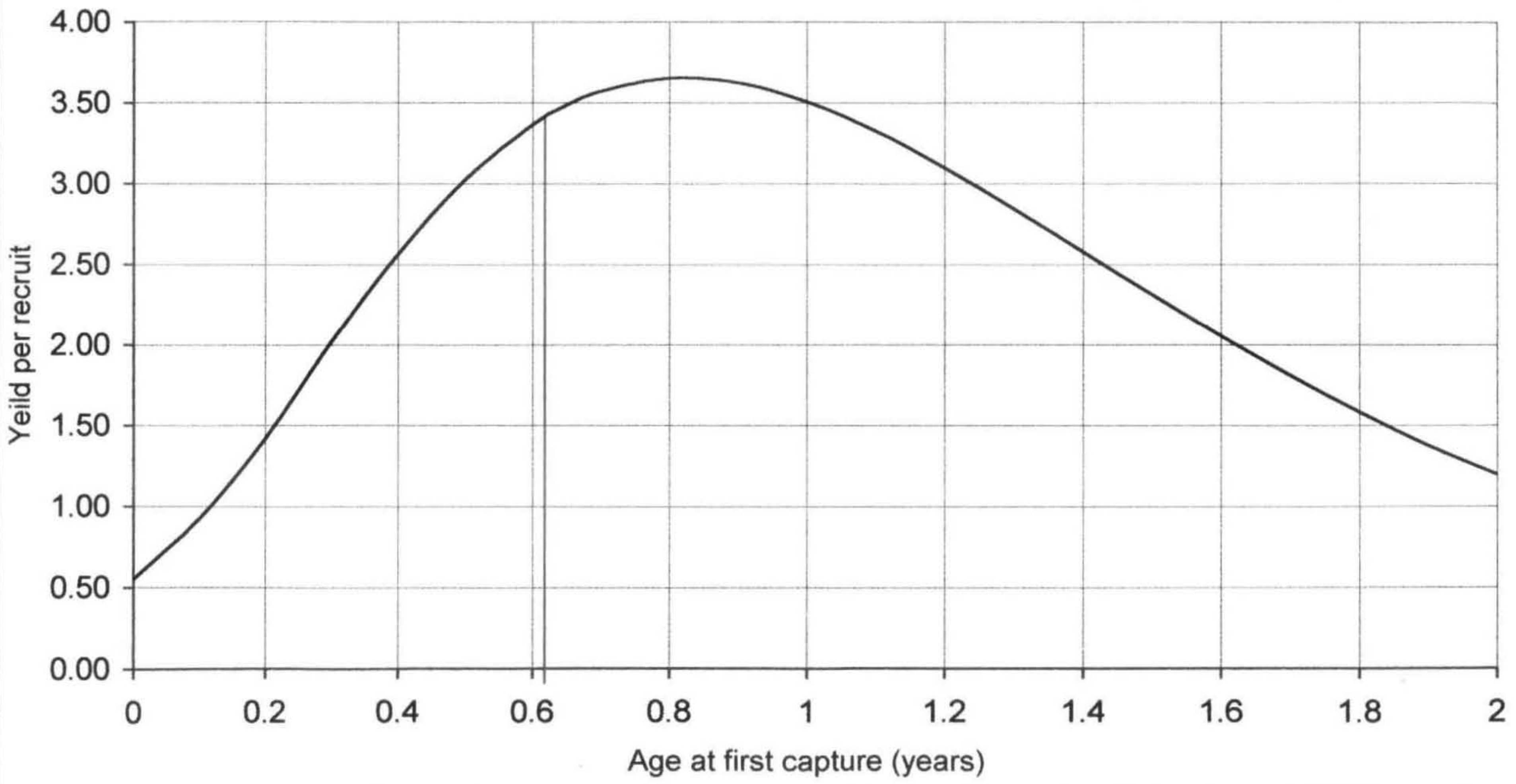


Figure: 72 Yeild per recruit (g) as a function of age at first capture in *Secutor insidiator* (current tc and Yw/R shown by a vertical line)

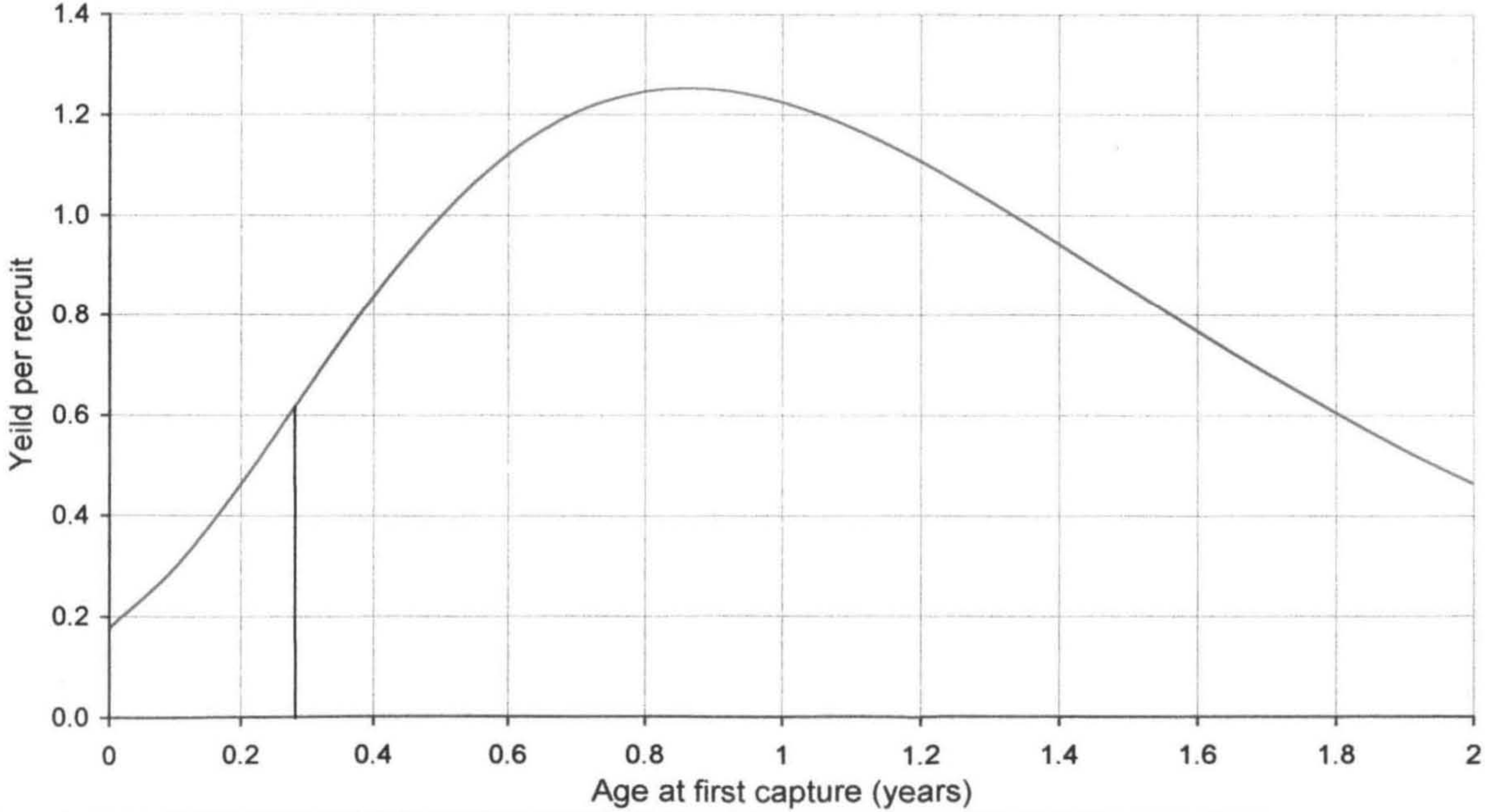


Figure: 73 Yeild per recruit (g) as a function of age at first capture in *Secutor ruconius* (current tc and Yw/R shown by a vertical line)

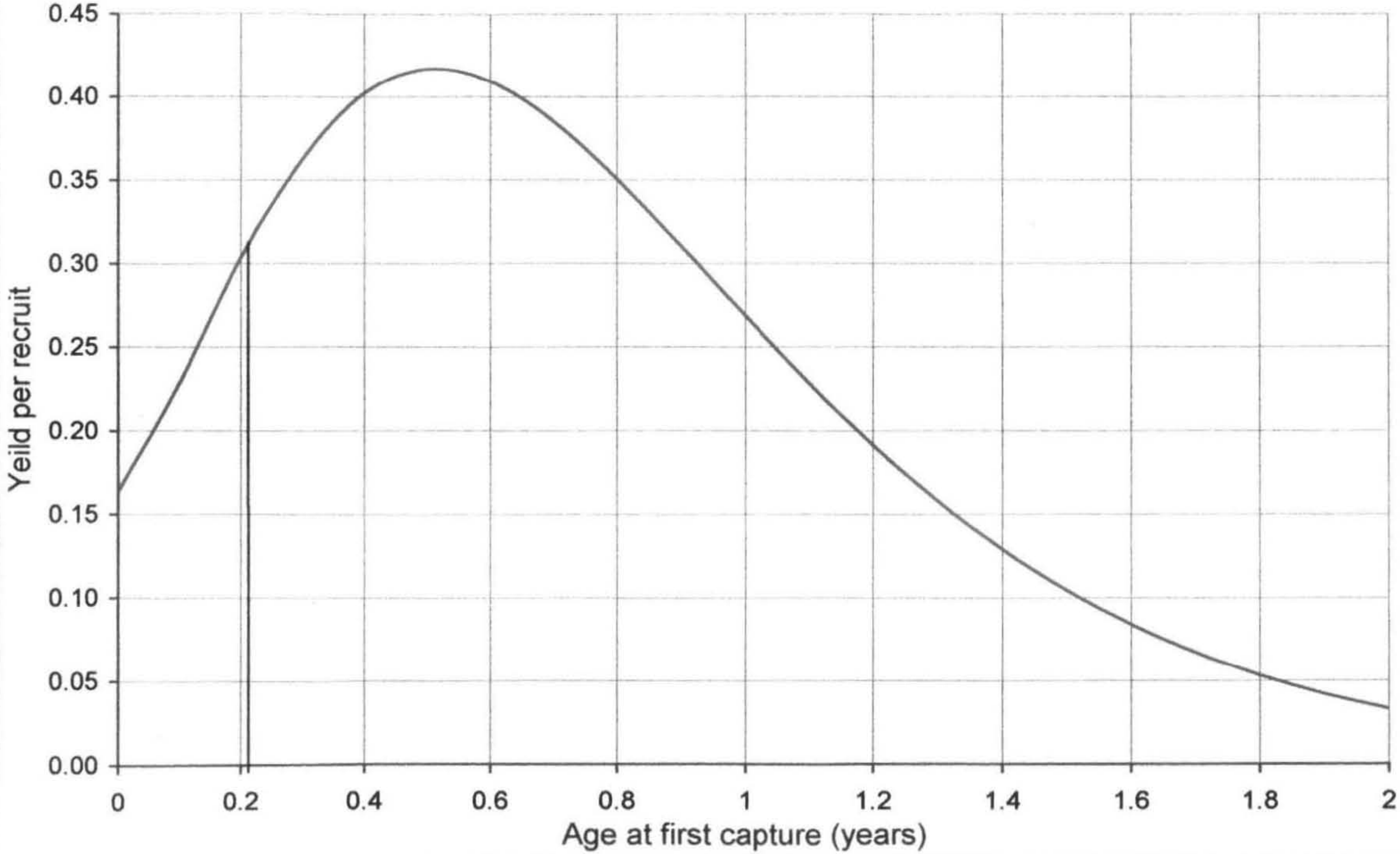


Figure: 74 Yeild per recruit (g) as a function of age at first capture in *Gazza minuta* (current $t_c$ and $Y_w/R$ shown by a vertical line )

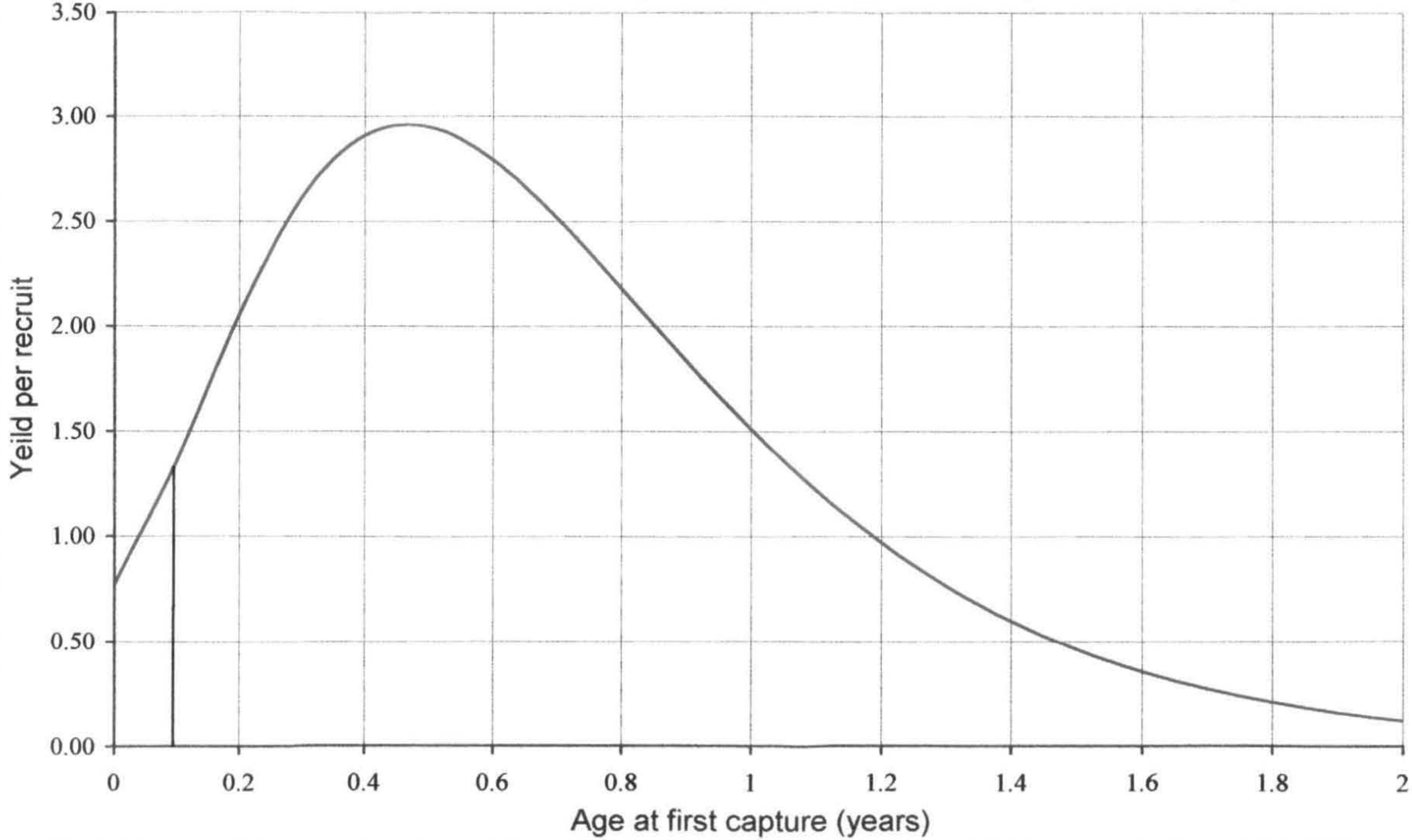


Figure: 75 Estimated yield of *L. splendens* as a function of fishing mortality rate expressed as percent of present

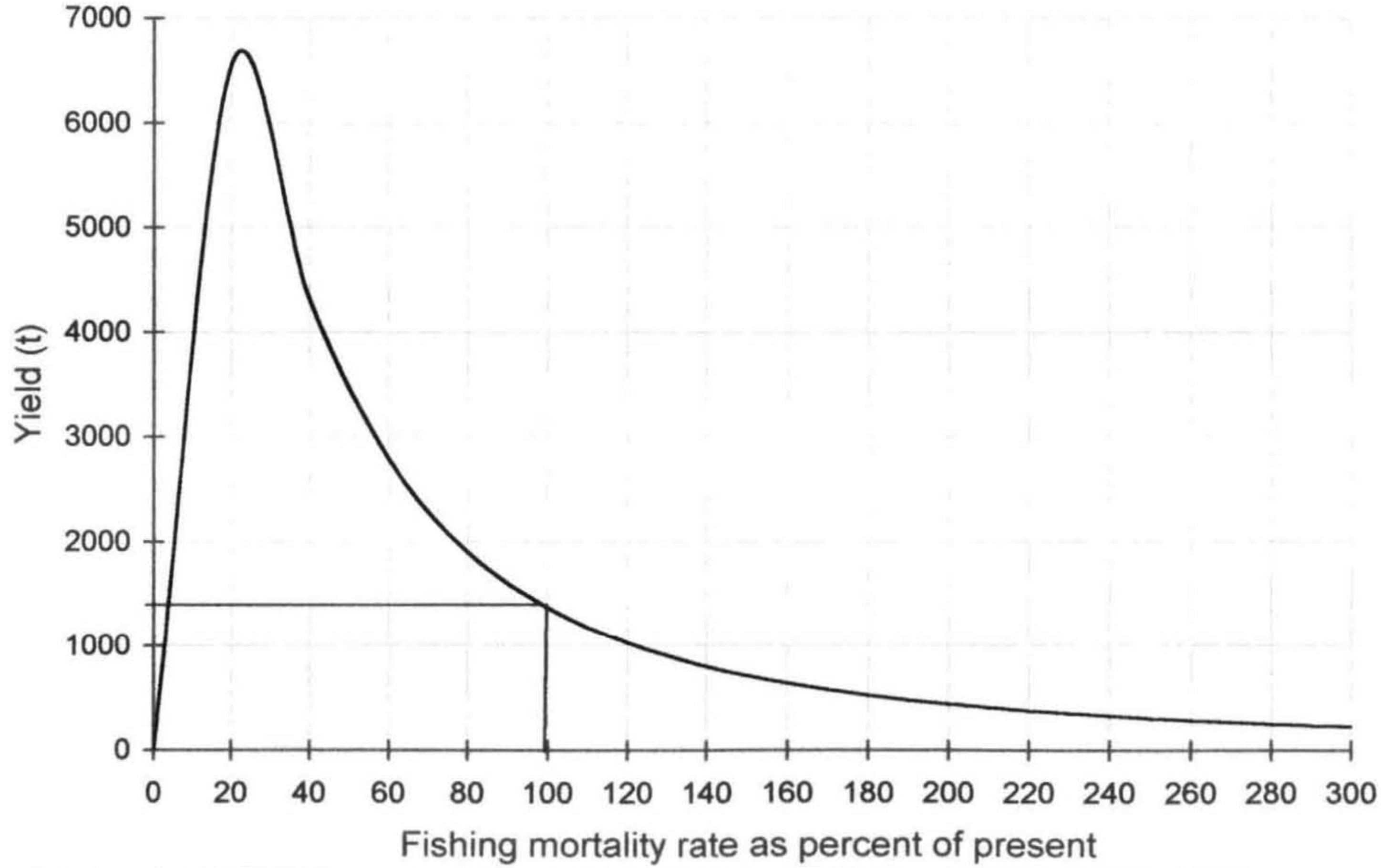


Figure: 76 Estimated yield of *L. brevirostris* as a function of fishing mortality rate expressed as percent of present

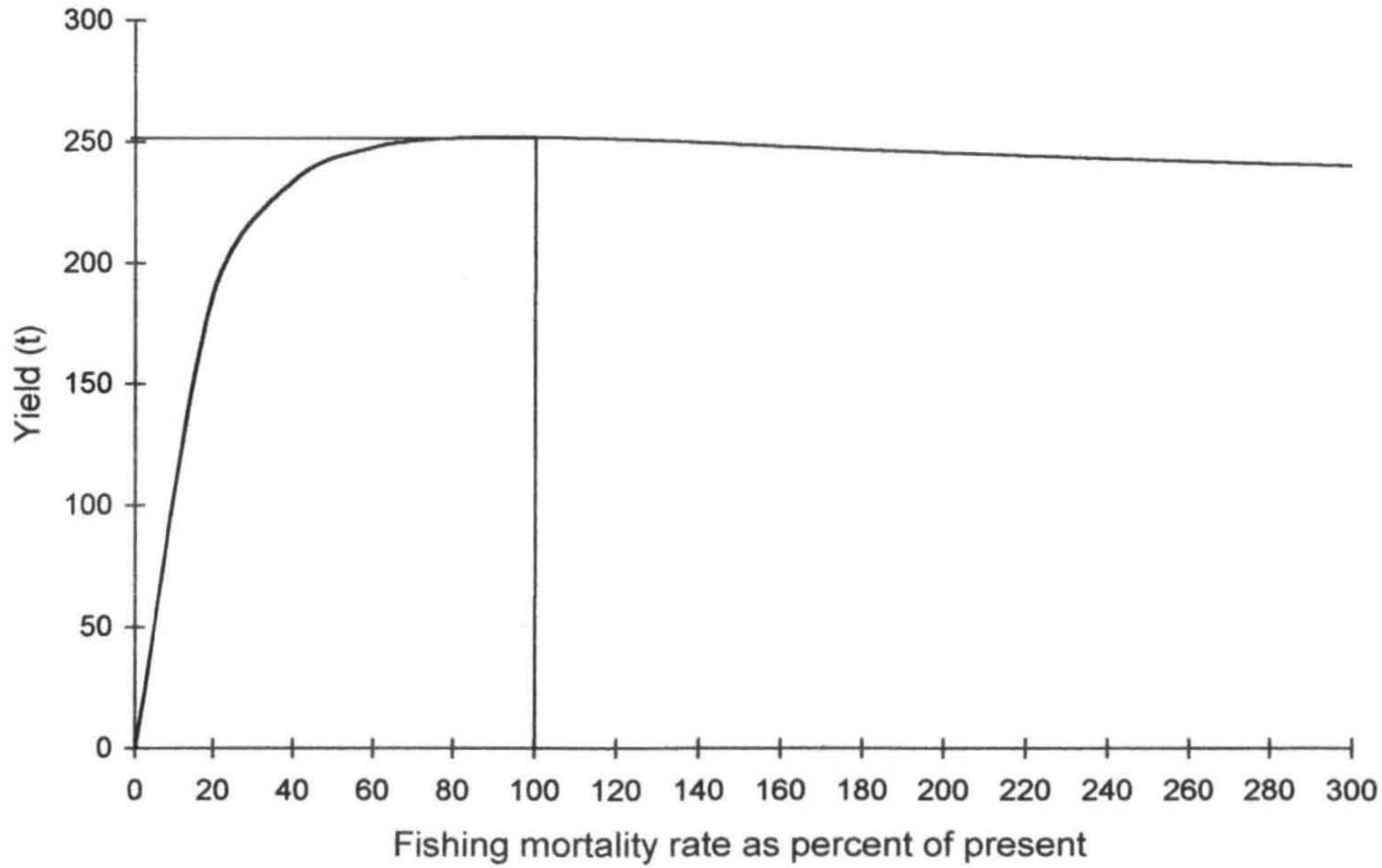


Figure: 77 Estimated yield of *S. insidiator* as a function of fishing mortality rate expressed as percent of present

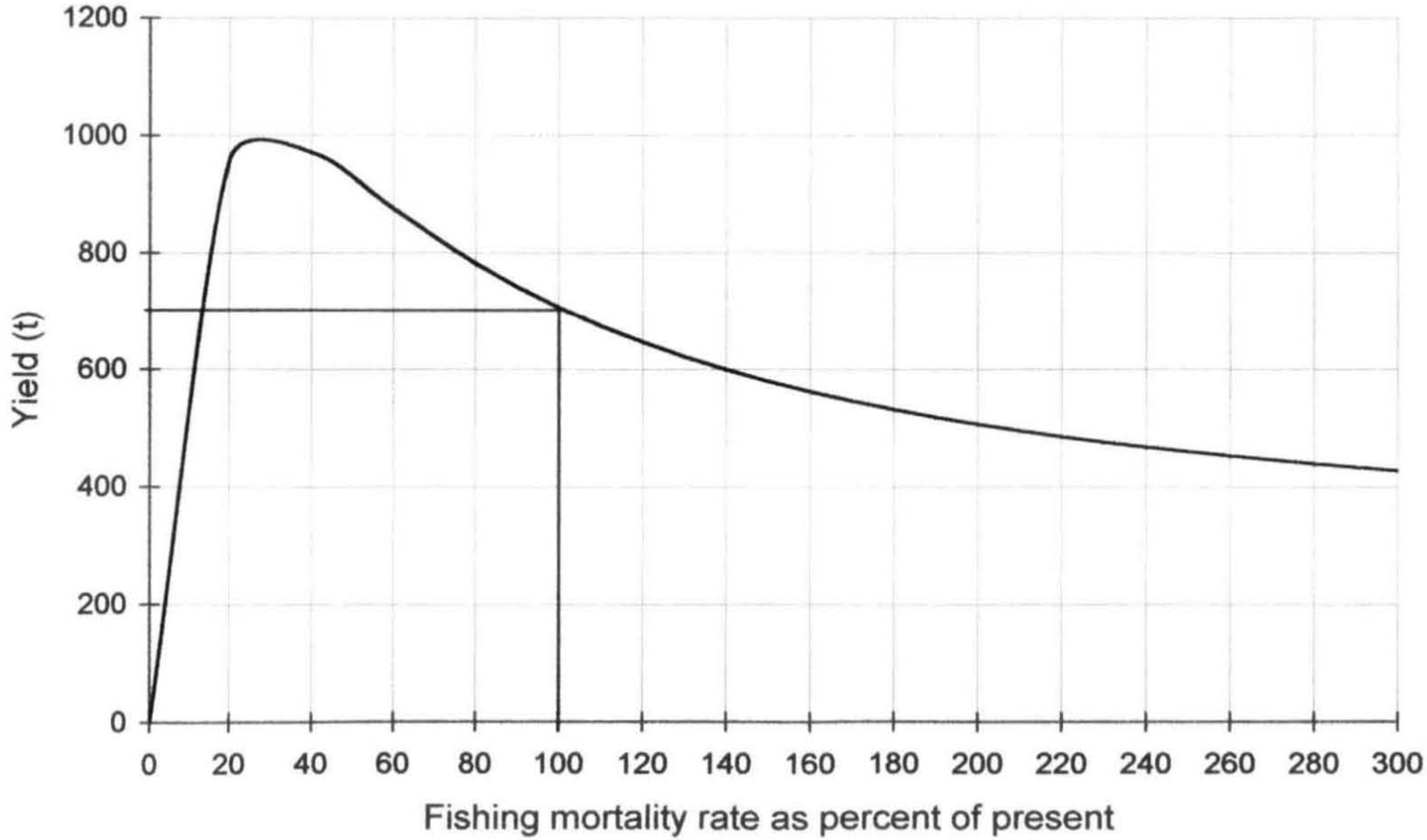


Figure: 78 Estimated yield of *S. ruconius* as a function of fishing mortality rate expressed as percent of present

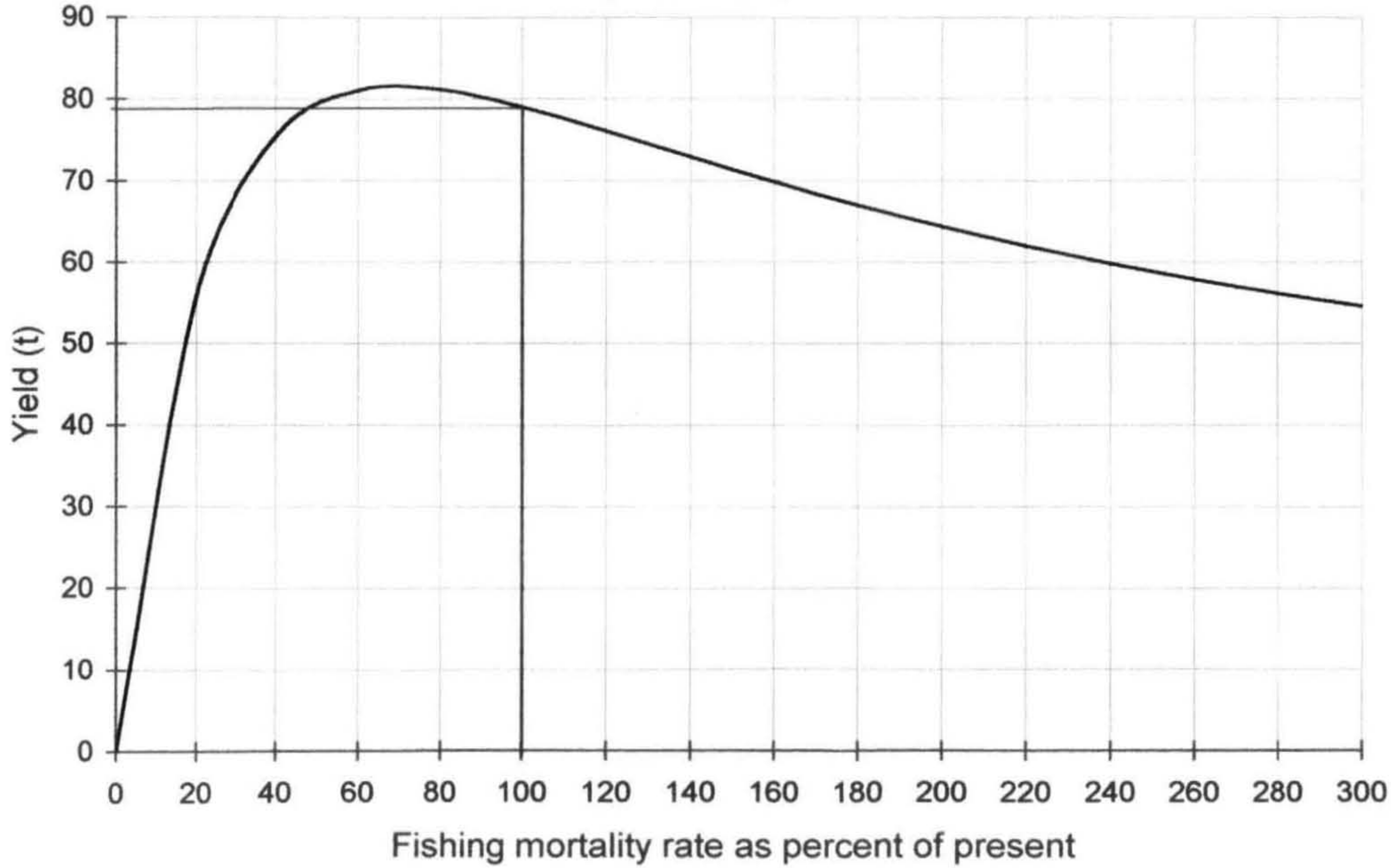


Figure: 79 Estimated yield of *G. minuta* as a function of fishing mortality rate expressed as percent of present

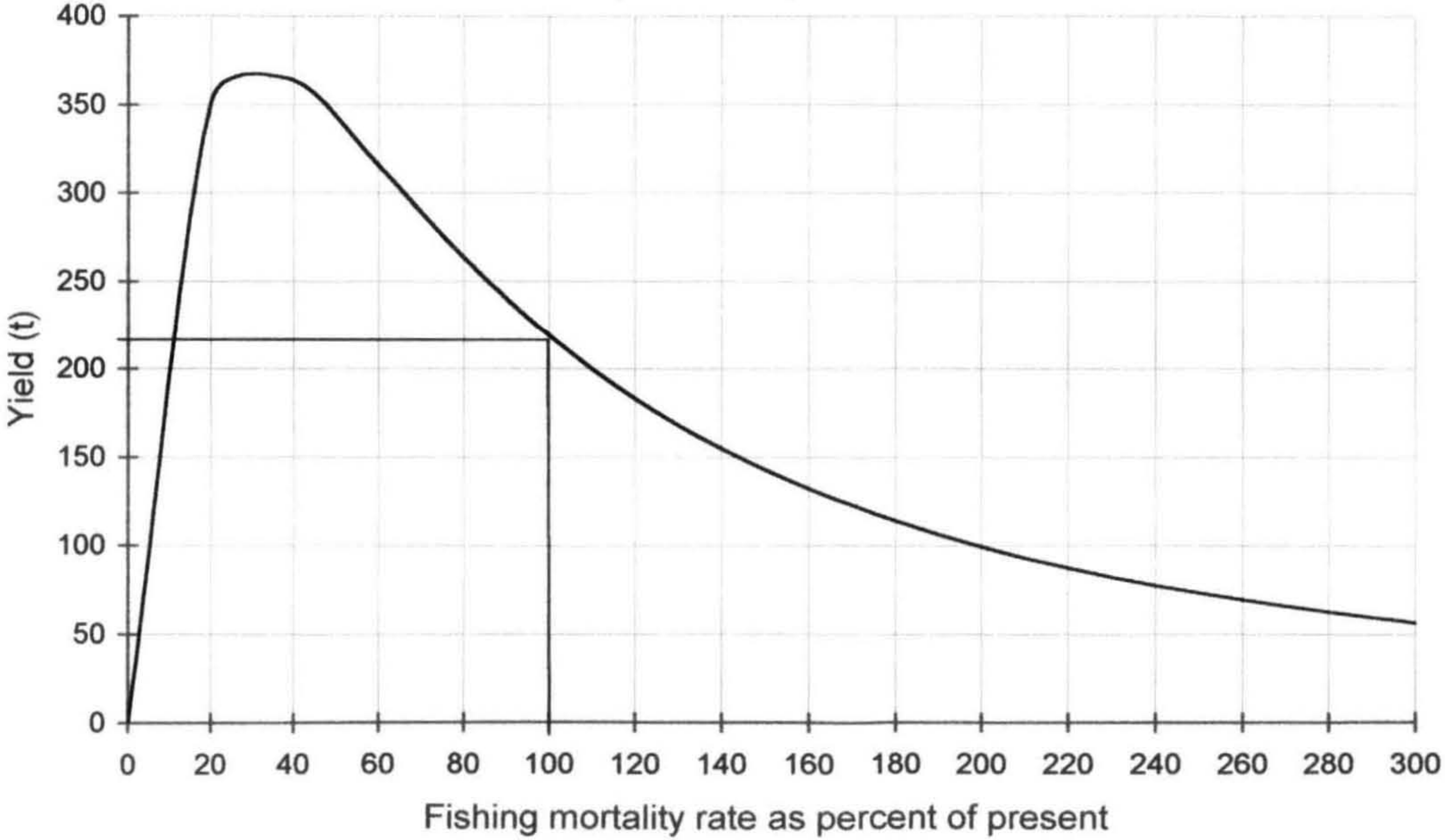
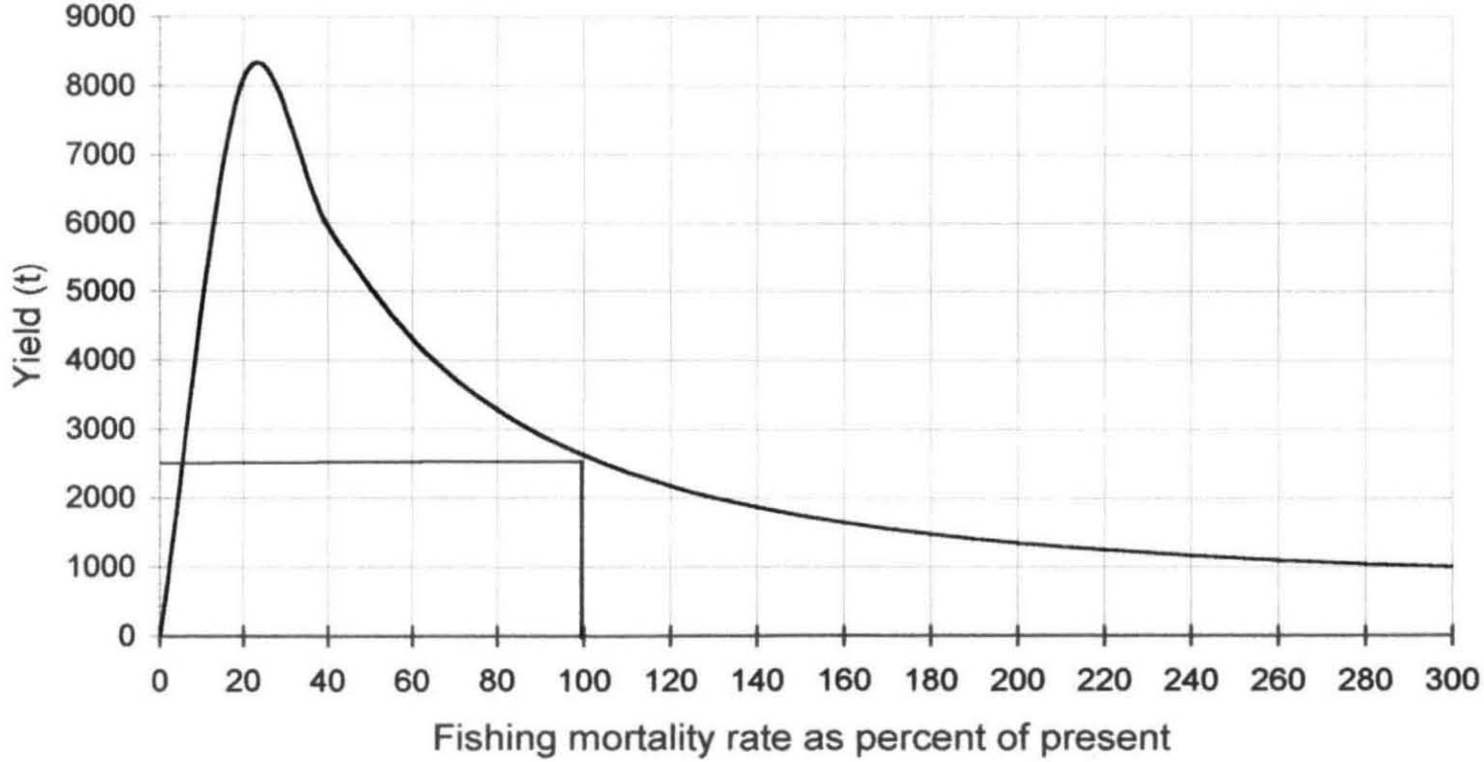


Figure: 80 Estimated yield of all five species as a function of fishing mortality rate expressed as percent of present



a substantial increase in the $t_c$, with reference to the species (Figures 81,82,83,84&85).

The estimated recruitment pattern suggests that it is continuous, with one peak in *L. splendens*, with out any major peak in *L. brevirostris,* with two peaks in *S. insidiator,* with one peak in *S. ruconius* and with two peaks (one being insignificant) in *G. minuta* (Figures 86,87,88,89&90).

## DISCUSSION

It is well known that living resources are renewable in nature and are therefore required to be managed properly to ensure sustainable returns on a continual basis. Among the marine living resources, the finfish and shellfish stocks are exploited by different ethnic and commercial groups having different interests. This has already led to undesirable consequences like conflicts, squirmishes, leading to governmental and political interventions. The overall marine fisheries resources situation in India is such that most of the resources, particularly those living at the bottom, are nearly fully exploited. The demand for fish food and trade has been growing with increasing human population. The situation therefore warrants intervention at different levels so as to ensure sustainability of the resources, improvement in employment generation and export and justice to the human population solely depending on fishing and related activities. For any management measure, the basic input is the scientific advice.

There are two different approaches of assessing the commercial fisheries data to be able to offer management advice: surplus production (Schaefer, 1954) and analytical (Beverton and Holt, 1957) models. The surplus production model is simple and is based on functional relationships between observable inputs (effort) and observable output (catch). It assumes that catch per unit effort is proportional to biomass and does not take into account the events occurring in the life history of a species. In the tropical seas particularly in the Indian seas, a large number of species having widely varying maximum lengths, growth characteristics and mortality characteristics

Figure: 81 Estimated yield of *L. splendens* as a function of age at first capture expressed as percent of present

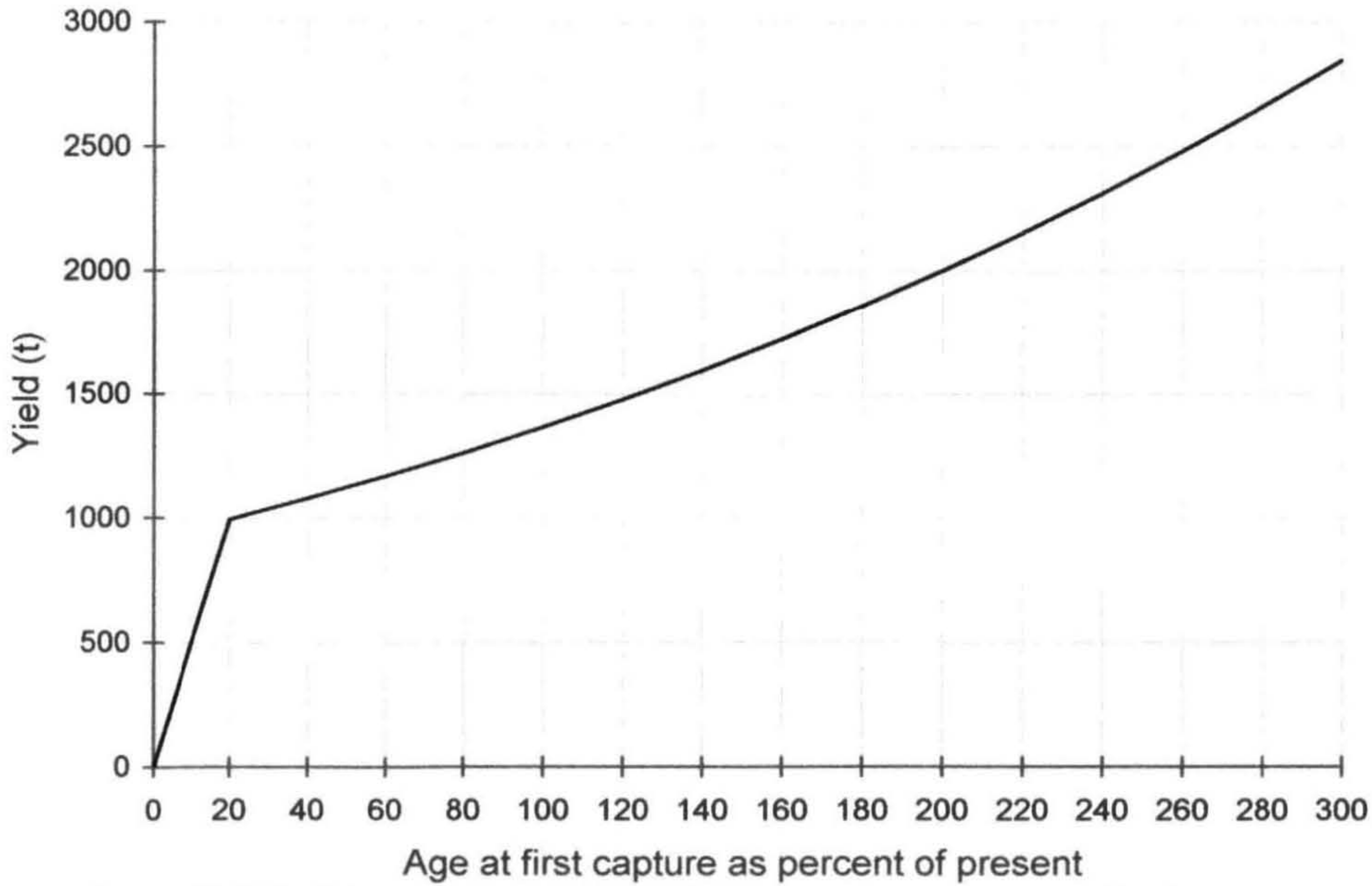


Figure: 82 Estimated yield of *L. brevirostris* as a function of age at first capture expressed as percent of present

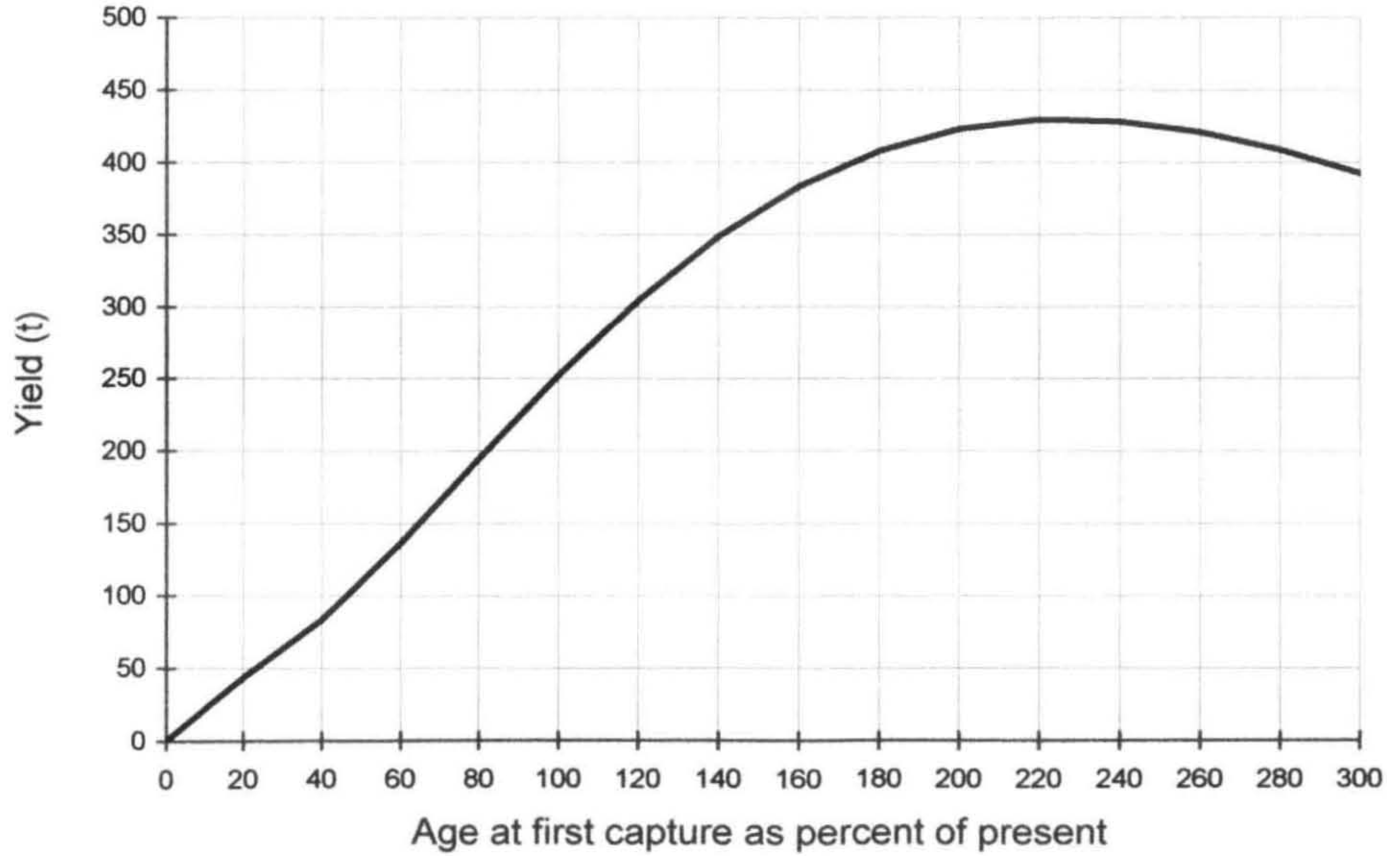


Figure: 83 Estimated yield of *S. insidiator* as a function of age at first capture expressed as percent of present

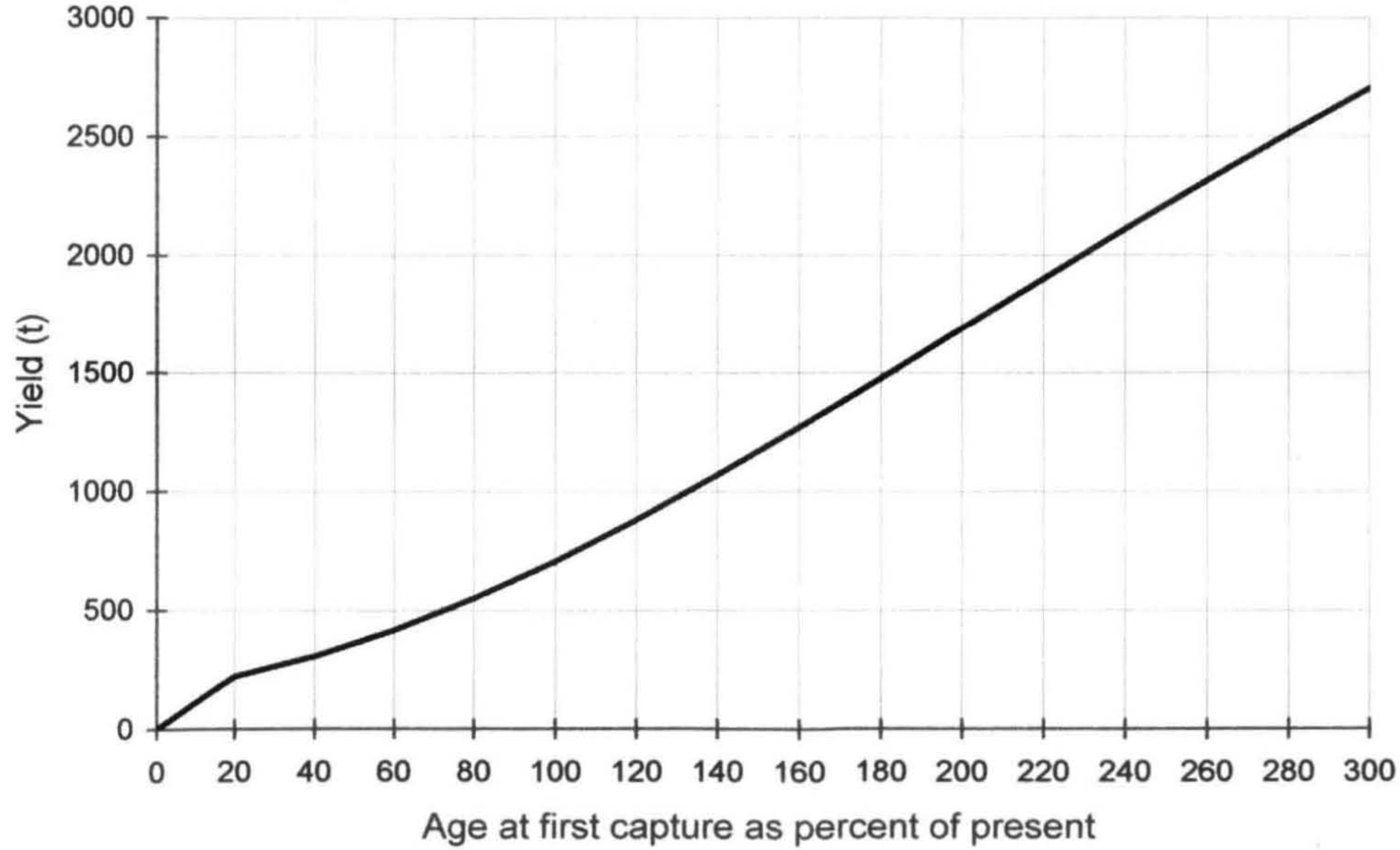


Figure: 84 Estimated yield of *S. ruconius* as a function of age at first capture expressed as percent of present

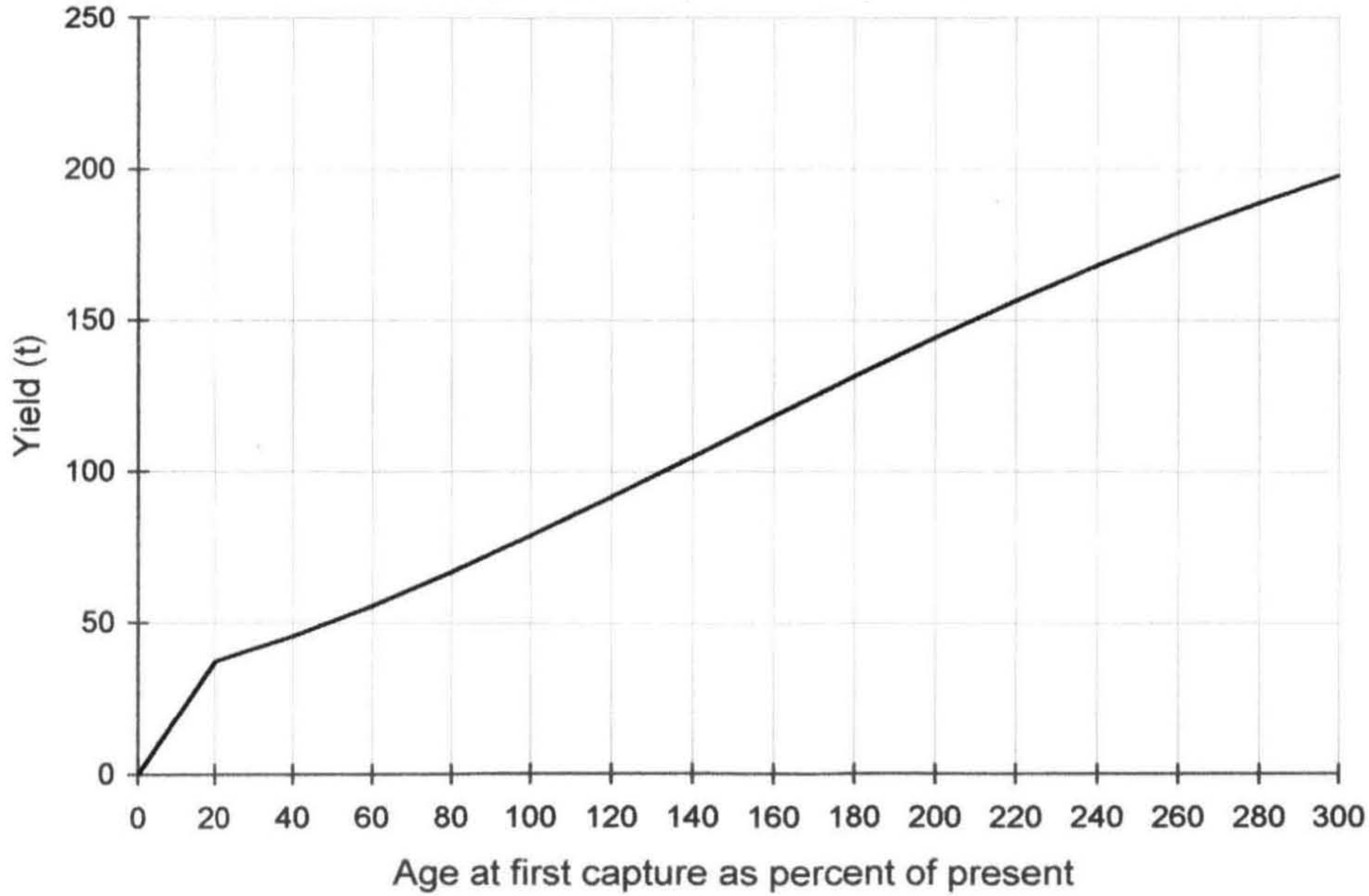
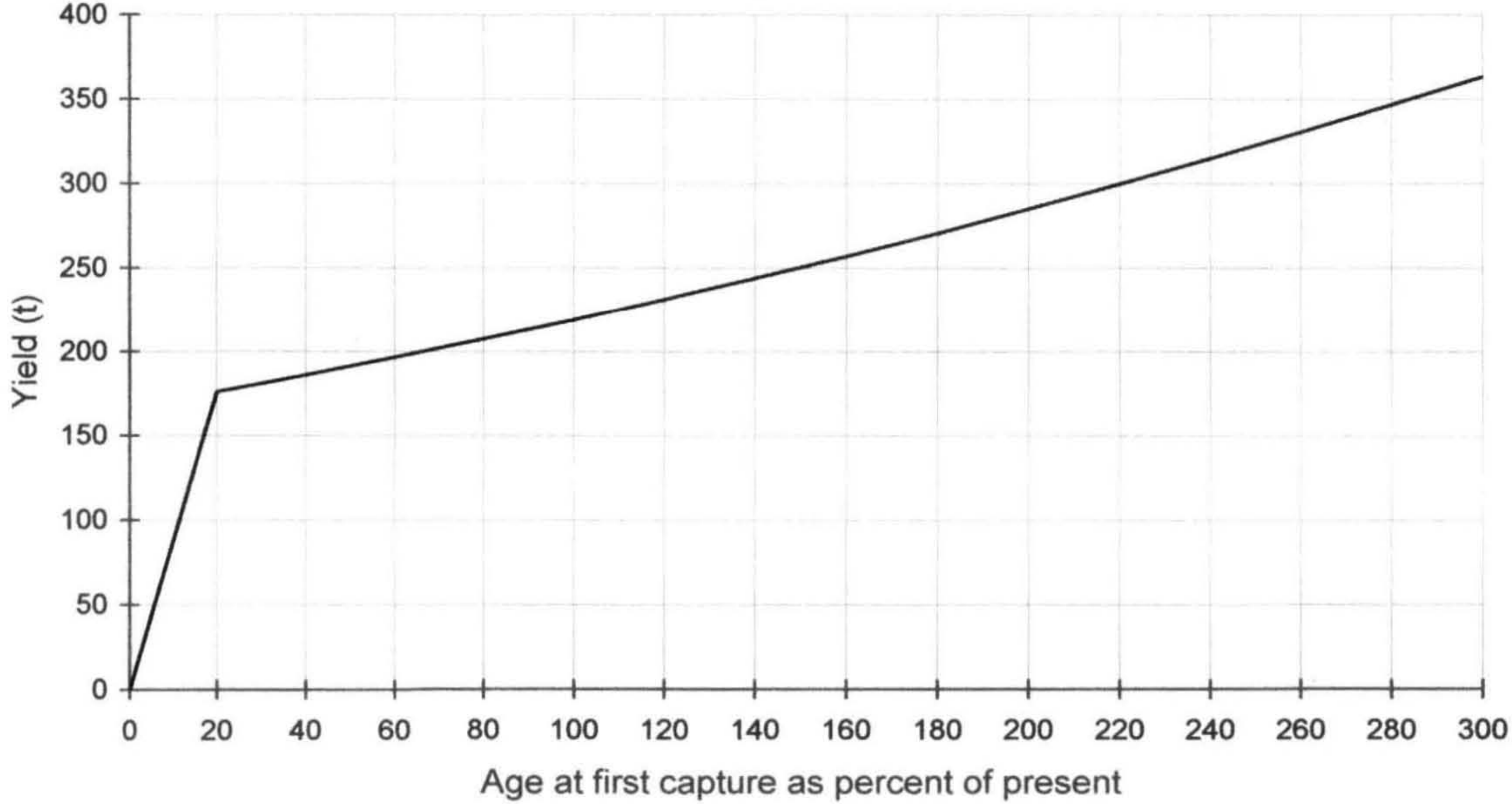


Figure: 85 Estimated yield of *G. minuta* as a function of age at first capture expressed as percent of present



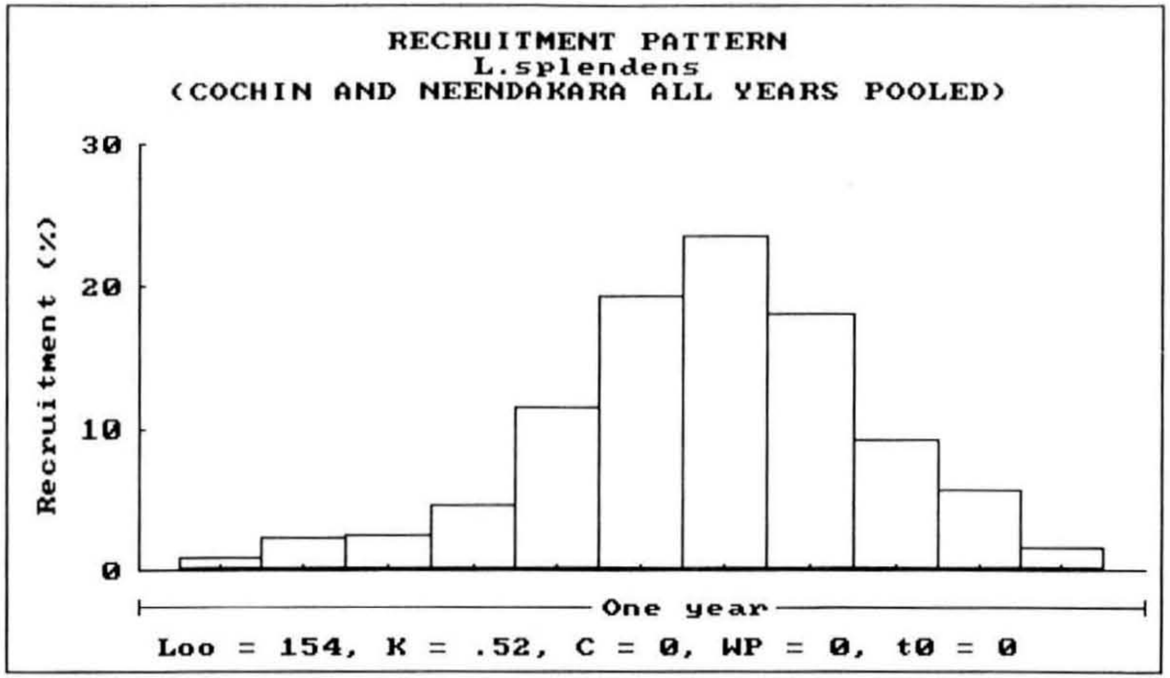



Figure. 86 Recruitment pattern estimated through FiSAT in *L. splendens*

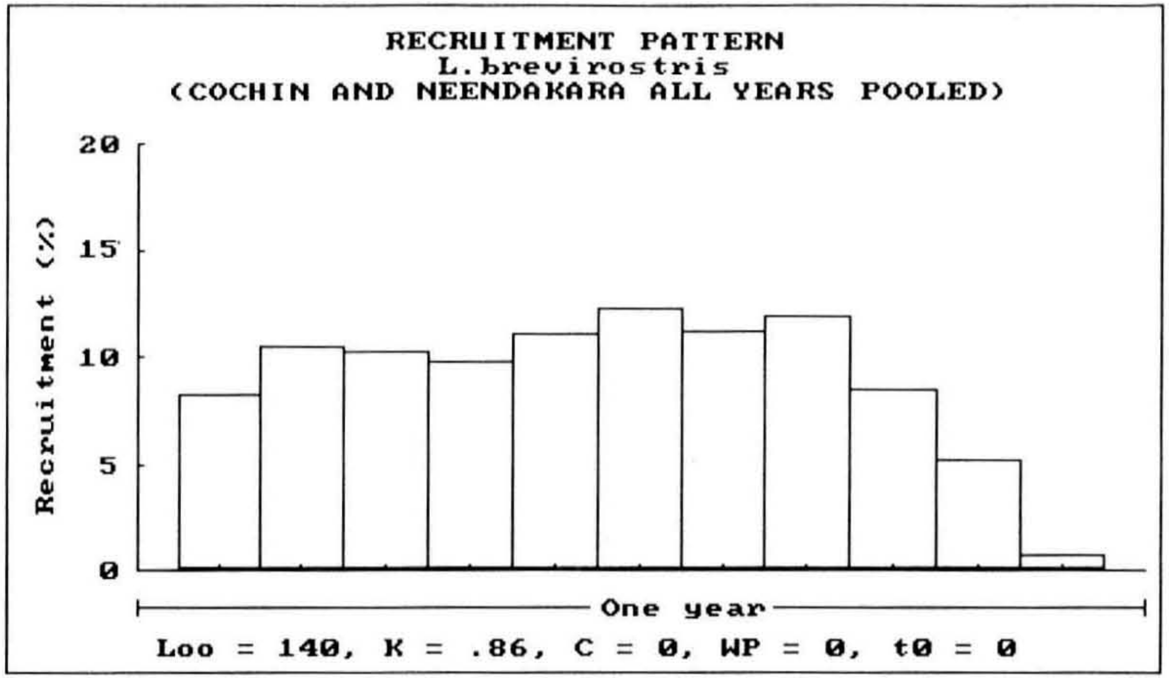



Figure. 87 Recruitment pattern estimated through FiSAT in *L. brevirostris*

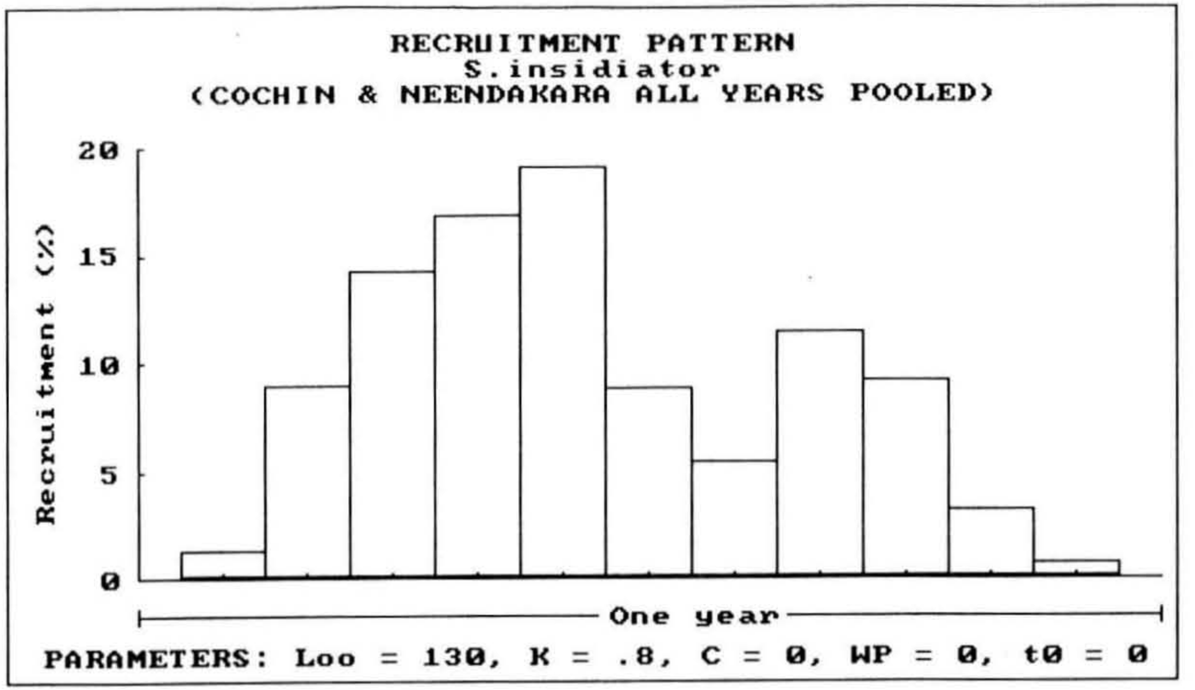



Figure. 88 Recruitment pattern estimated through FiSAT in *S. insidiator*

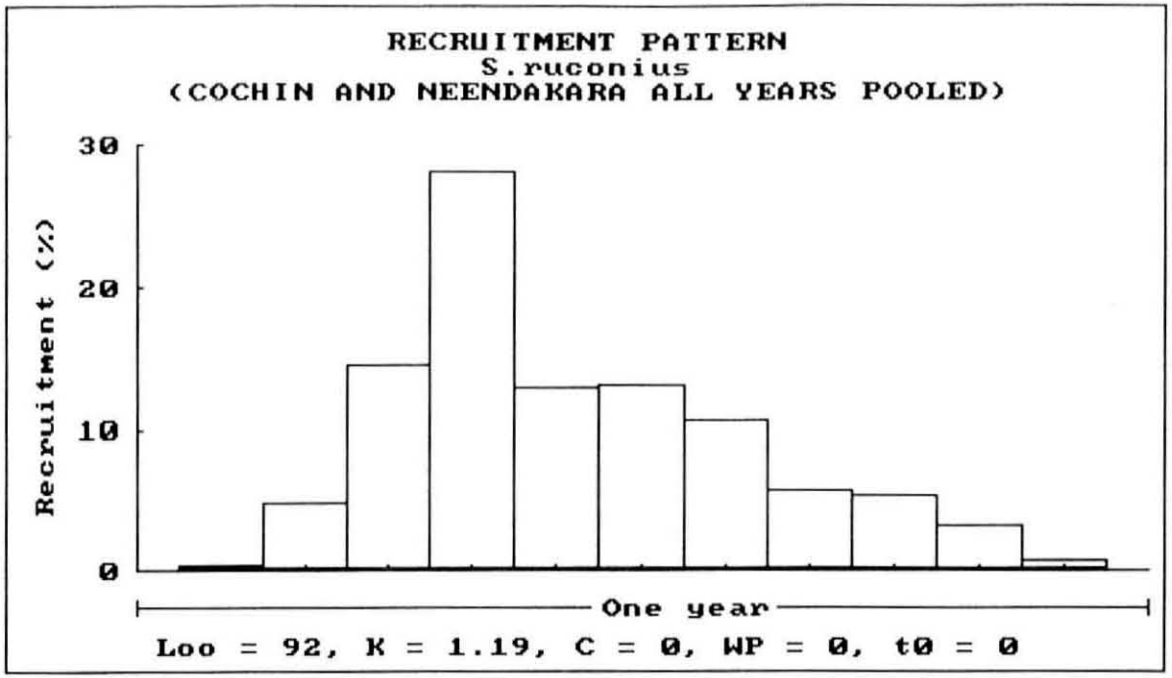



Figure. 89 Recruitment pattern estimated through FiSAT in *S. ruconius*

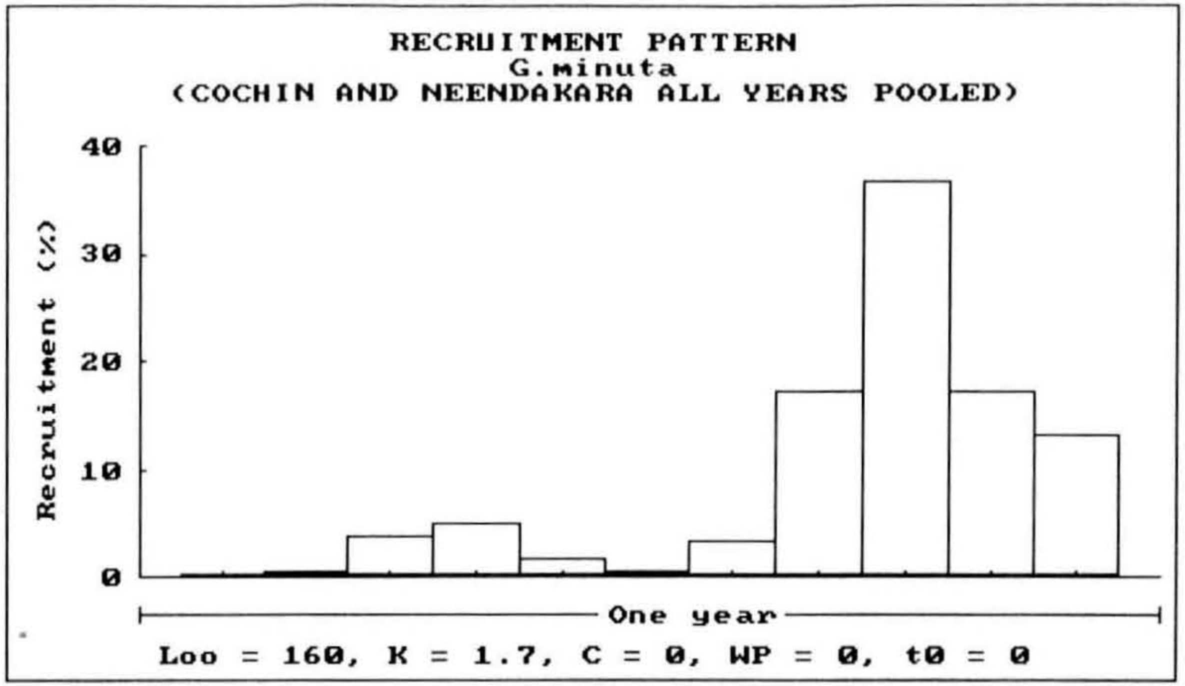



Figure. 90 Recruitment pattern estimated through FiSAT in *G. minuta*

are exploited together in the same gear and in different gears. More over, the surplus production model has the significant draw back that it "is ostensibly empirical with no theoretical basis" (Larkin, 1982) and, the "real fish stocks do not fit the simple models", besides, the curve of catch as a function of effort usually does not have such a sharply defined maximum as the parabola corresponding to the simplest assumption nor does the maximum always occur "tidily at half the unexploited population" (Gulland, 1983). Further, "what we gain in simplicity with the surplus production models has the cost of a number of assumptions on the dynamics of fish stocks, which may be (and nearly always are) impossible to justify " (Sparre, 1985). The surplus production models however are very valuable in assessing the stock size in virgin grounds and also in situations where a first approximation of the size of the population of all the species is necessary for taking certain policy decisions.

On the other hand, the analytical models which take into account the events in the life history (reproduction, recruitment, growth, mortality etc) of a particular species/stock have the major advantage of the "existence of an established body of theory and methods for dealing with single species"(Larkin, 1982). A fishery scientist, therefore naturally tends to investigate into the various such events and try to take them into account before coming up with a management advice. The single species assessments afford an understanding of the health of the species/stock, but such assessments under isolation, in spite of being based upon a sound theory and, taking into account the various events in the life history, do not generate meaningful management options in a multi species/mixed fisheries situation because the requirements of management of individual species in the multispecies mix may differ significantly. The regulation, however, has to be applied uniformly to all the species for the very simple reason that all these species are caught simultaneously by the same gear and in some cases by different gears in the same ground. To be able to assess the multispecies mixed fisheries resources on the basis of the single species assessments, Beverton and Holt (1957), suggested the yield per recruit curves to be converted into value curves and pooled for different species after standardising the fishing mortality rate. Following this, Murty (1985, 1989), Sparre (1985), explained the method of utilizing single species assessments for drawing up of management strategies of multispecies/mixed fisheries. The present study has considered the data of five species of silver bellies from off Kerala coast with the objective of assessing the resource situation of silver bellies vis-à-vis their exploitation in the region. In *L. splendens,* the present F is much beyond the $F_{max}$ (Figure 65), close to the $F_{max}$ in *L.brevirostris* (Figure 66), less than $F_{max}$ in *S. insidiator* (Figure 67), and beyond the $F_{max}$ in *S. ruconius* (Figure 68) and *G. minuta* (Figure 69). The yield as a function of fishing mortality rate expressed as percent of the present value (under the current $t_c$) shows that maximum yield is possible in the case of *L. splendens* at around 25% of the present F (effort) (Figure 75), at the current F in the case of *L. brevirostris* (Figure 76), about 25% of the current F in *S. insidiator* (Figure 77), about 65% of the current F in S. *ruconius* (Figure 78) and at about 30% of the current F in *G. minuta* (Figure 79). In all the five species (Figure 80) maximum yield of around 8000 t which is nearly 300% of the present is possible at around 23% of the present fishing effort, It may be noted that the current yield of all the five species is of the order of 2600 t (Figure 91) The situation can be better seen in (Figure 92) where the yield as percent of present is plotted against the fishing mortality rate, which is also expressed as percent of present rate. By reducing the effort to around 25% of the present, the yields would increase to about 300% of the present

The yield per recruit as a function of age at first capture (under the current F) in the five species suggests that the current values of $t_c$ are less than those which would ensure higher yields in all the five species. It is also clear (Figure 93) that the yield of these species increases under the current effort itself, if the $t_c$ (i.e. cod end mesh size) is increased to 200% of the present and a total of 170% of the present yield could be obtained (Figure 93).

The above analyses clearly lead to two major conclusions

1. the effort needs to be reduced by about 80 % (since F is proportional to fishing effort) and

Figure: 91 Estimated yield of all five species as a function of age at first capture expressed as percent of present

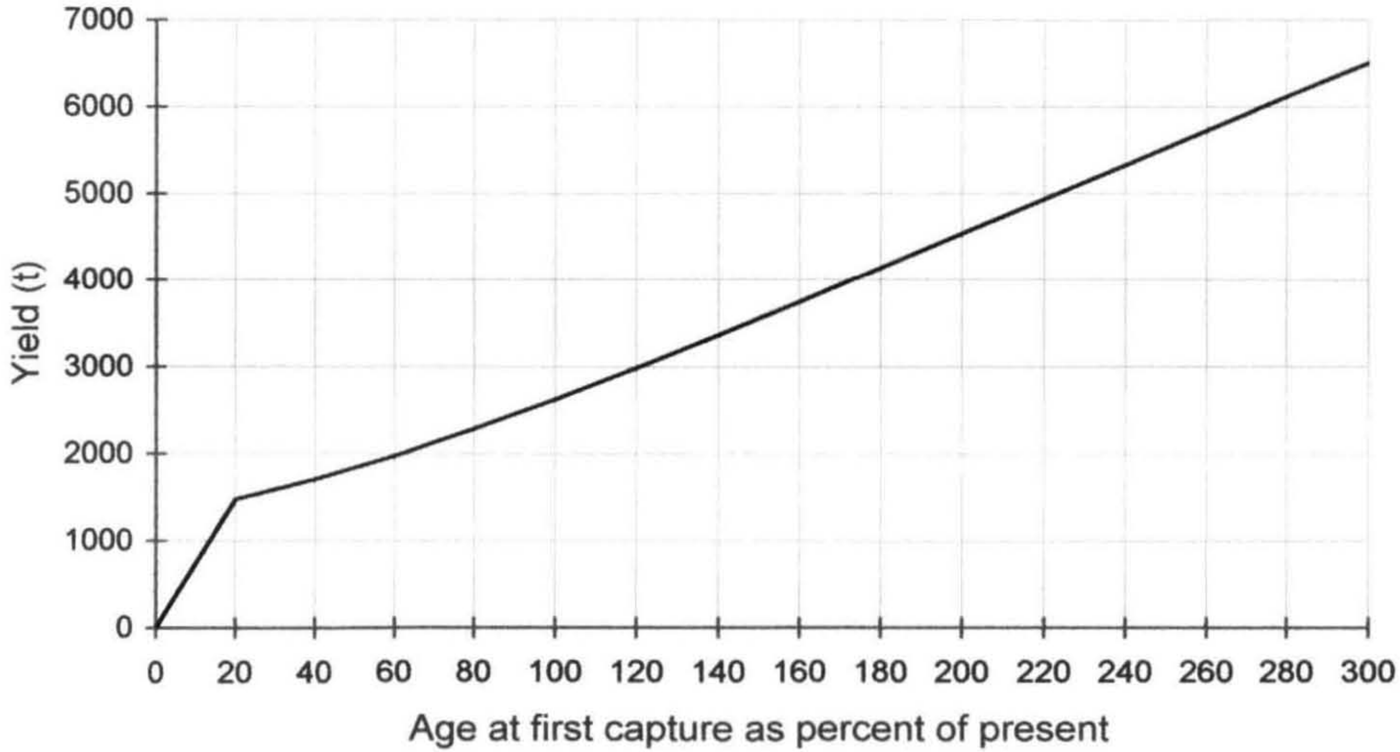
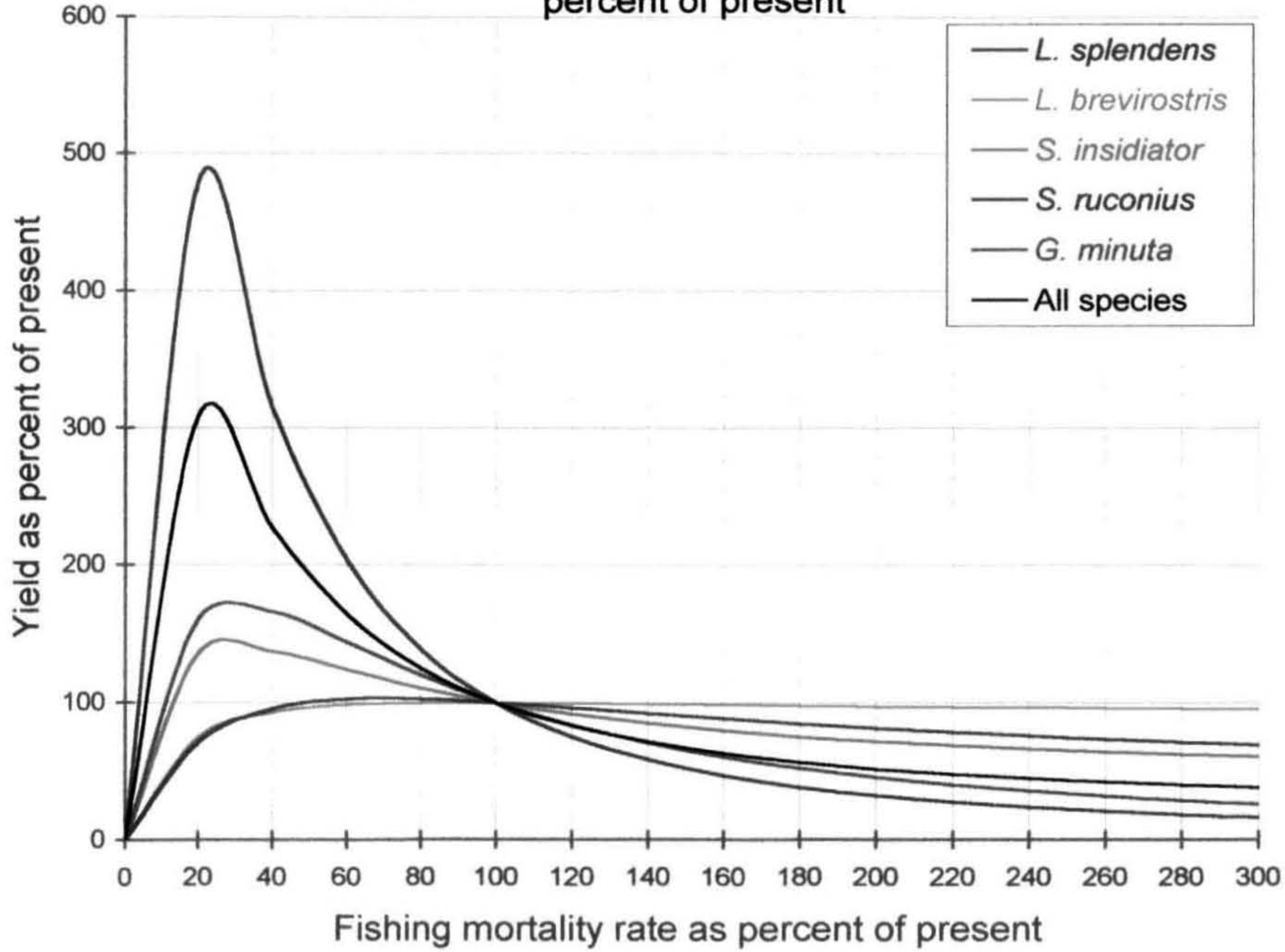


Figure: 92 Estimated yield as percent of present (in different species and all species together) as a function of fishing mortality rate also expressed as percent of present



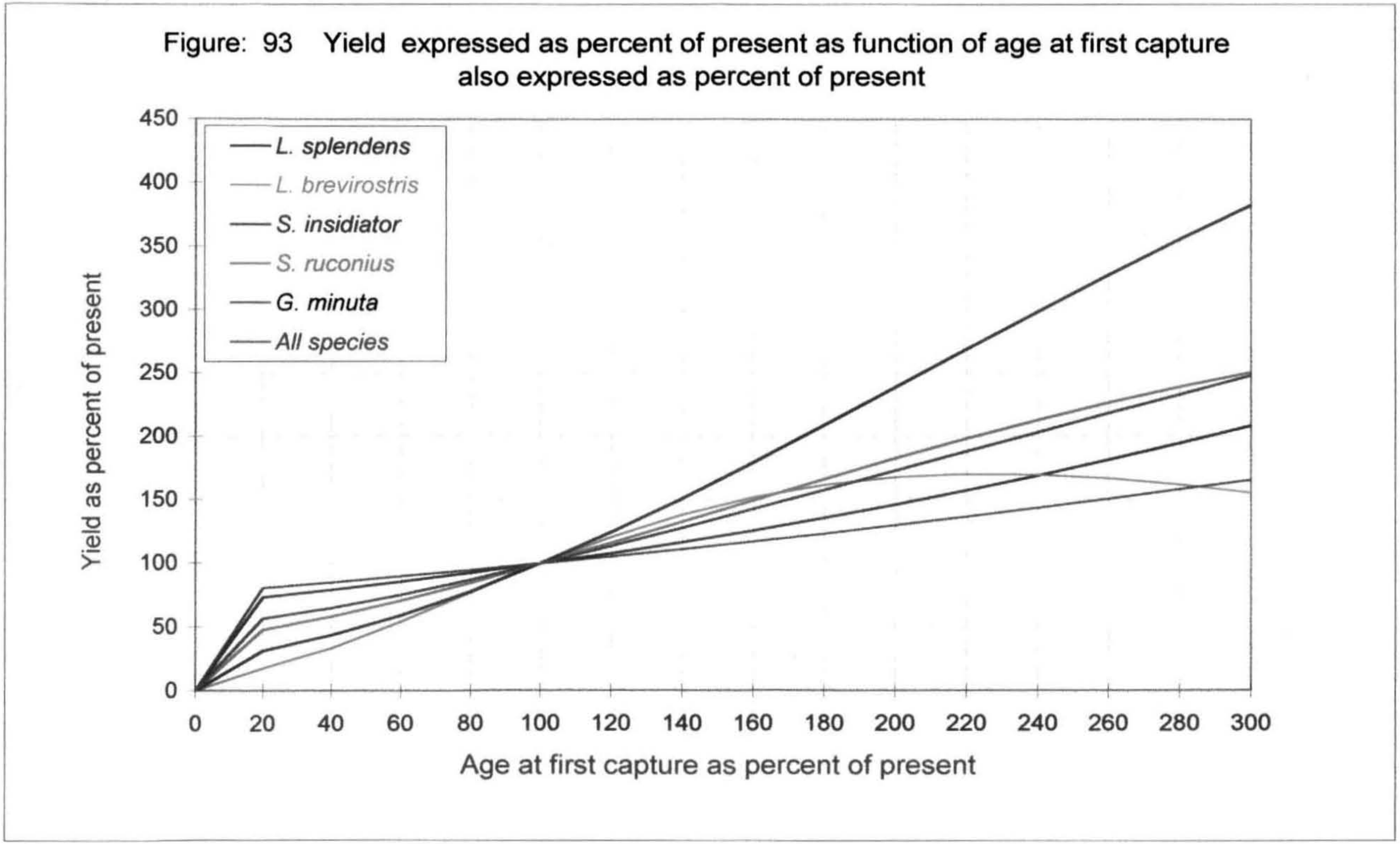


Figure: 93 Yield expressed as percent of present as function of age at first capture also expressed as percent of present
L. splendens
L. brevirostris
S. insidiator
S. ruconius
G. minuta
All species
Yield as percent of present
Age at first capture as percent of present
0
50
100
150
200
250
300
350
400
450
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

2. the cod end mesh size of trawl nets (since the age at first capture is proportional to cod end mesh size) can be increased substantially.

Since the five species considered here contribute to nearly 90 % of silverbelly landings in the state, the present results can safely be taken as reflecting the situation in all the silverbelly species in the region. However, the trawl fishery is not dependent on silverbellies alone. When studies similar to the present one are made on all the other major species contributing to the fishery, it will be possible to arrive at the best possible combination of fishing effort and cod end mesh size depending upon the species and quantities required. It should be noted that the analytical model of Beverton and Holt (1957) used here assumes the population to be in equilibrium state with the natural mortality rate being constant, growth to be constant, recruitment to be constant and the fishing mortality rate for all ages beyond $t_c$ to be constant. Hence maximum equilibrium yield of about 8000 t of silver belly can be obtained at around 30% of the currently expended effort with the present cod end mesh size. If the cod end mesh size is increased further, with the reduced fishing effort, the equilibrium yield could still be higher. The present results, however, cannot be taken as suggestive of overexploitation of silverbelly resources, because of the equilibrium assumption: at the current effort and cod end mesh size levels, the equilibrium yield is around 2600 t of the five species. Immediate reduction of fishing effort on the basis of the present results would lead to a drastic decline in the landings immediately, but if the so reduced effort is maintained at the same level constantly, the yield would continue to grow over a period of time and then attain equilibrium level. In the long-term predictions it is necessary to realize that the yields are equilibrium ones and any regulation should be done keeping in view the long-term changes and transition from one equilibrium to another.

# Chapter V

# Fishery

# FISHERY



## INTRODUCTION

Silverbellies constitute an important group of demersal fishes, constituting commercial fisheries of regional importance. Mostly they inhabit the shallow coastal waters , moving in shoals near the bottom. Silverbellies are known to be most abundant in shallower regions in the sea (James, 1973 a; Pauly , 1977a,b; Pillai and Dorairaj , 1985; Sudarsan *et al,* 1988; Sivaprakasham *et al,* 1991) up to 40 metres depth, though they are available in depths of 100-150 metres also (Sudarsan *et al.,* 1988). *Leiognathus bindus* was reported to be available at even 160 metres in Australian waters (Jones, 1985) Most of them are small, attaining maximum lengths of about 10-11 cm; *Leiognathus equulus* is reported to attain about 25 cm length . The bulk of the catch of silverbellies is taken by trawlers. Though these fishes are small and considered as trash at certain places , the quantities landed make them important both from the fishery and management points of view.

## SILVERBELLY FISHERY OF INDIA

The silverbelly landings in India have shown a steady increase from 44140 tonnes in 1969 to 69915 tonnes in 1994, thereafter falling to 53498 tonnes in 1999, with years of maximum abundance in 1983 (91733 tonnes) and 1982 (72668 tonnes) (Figure 94). On an average silverbellies contributed to 3.19 % of the total marine fish landings from India during the thirty year period from 1969 to 1999. Though they are available all along the coasts of maritime states of India ,the bulk of the landings come from the southern sector of both the coasts. Tamilnadu contributed to the bulk of the landings (67.46%), followed by Kerala (12.28%), Andhra Pradesh (8.82%), Karnataka (4.91%), Gujarat (1.38%),West Bengal (0.79%) ,Orissa (0.71%), Pondicherry (1.1%), and Maharastra (0.56%), and Andaman and Nicobar and Lakshadweep ( 0.71 %) (Figure 95) Thus it can be seen that the major share of the silverbelly production in India comes from the east coast, accounting for about 80 %of the total silverbelly production in the country.

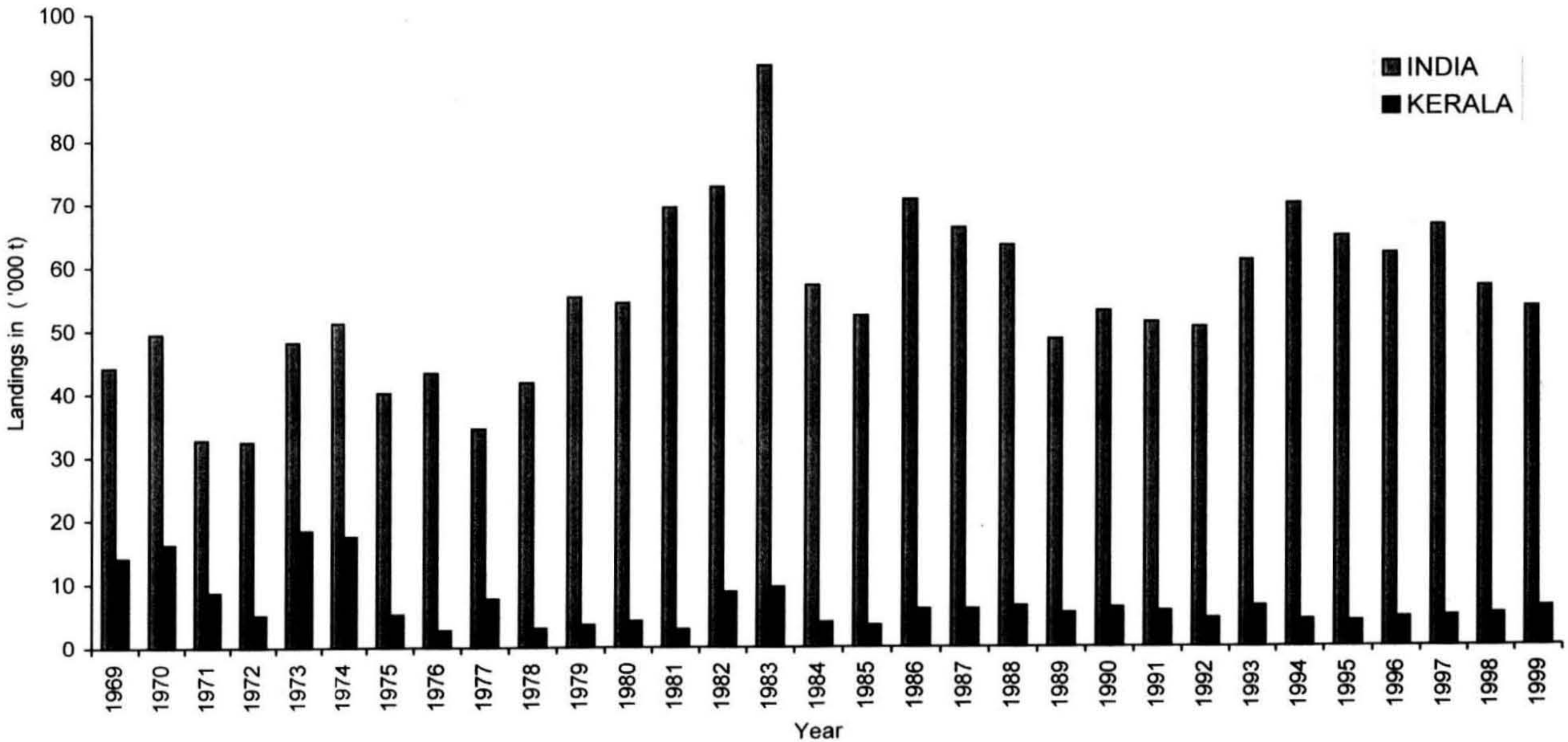



Fig. 94 Estimated landings of silverbellies in India and Kerala during 1969-1999

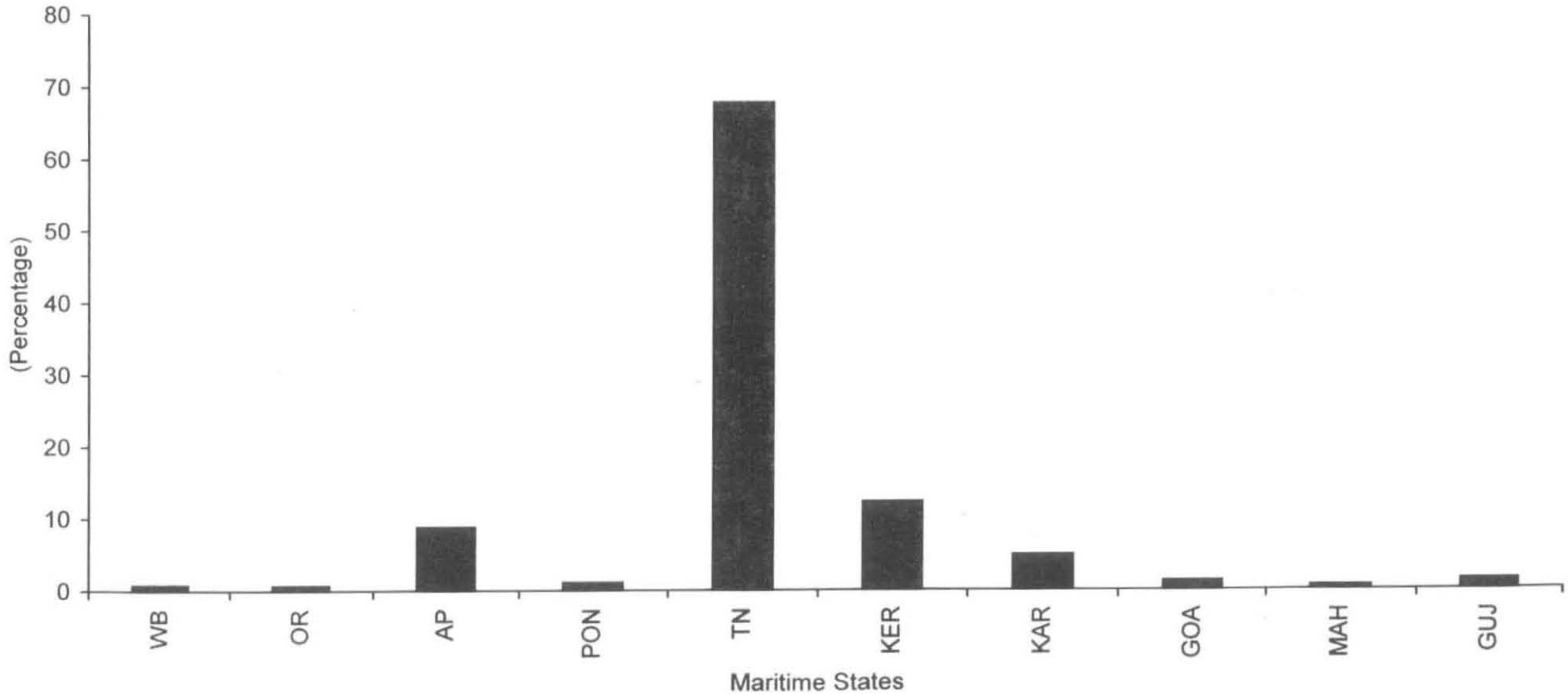



Fig. 95 Contribution of different maritime states of India to the silverbelly landings (1969-1999)

Twenty one species of silverbellies have been reported till date from the Indian seas, while in the present study sixteen species have been collected. Only about eight species, viz., *Leiognathus splendens, L. brevirostris, L. bindus, L. equulus, L.dussumieri, L. jonesi, Secutor insidiator* and *Gazza minuta* appear to be important from the fishery point of view from different regions along the coast (James, 1981). The species composition and the dominant species are different in different regions along the Indian coast.

Arora (1952), studied the fishery and biology of *Leiognathus splendens* , from Thangachimadom, in the Rameswaram island. Balan (1963), studied the fishery and biology of *L. bindus* along the Calicut coast . James and Adolph (1965), studied their resource from the trawl catches of the Indo-Norwegian project boats operating along the Gulf of Mannar and Palk Bay region. James (1973 b) studied the fishery potential of silverbellies along the Indian coast and summarised the regions of abundance, dominant species and catch potentials of silverbellies along the different areas along the Indian coast. Rao (1973) studied the distribution pattern of silverbellies in India. Venketaraman and Badrudeen (1974), studied the diurnal variations in the distribution of silverbellies in the Palk Bay region. Murty (1986b) also stated a similar pattern along West Bengal. James and Badrudeen (1975, 1981 studied the fishery of *Leiognathus brevirostris* in the Palk Bay and Gulf of Mannar and of *Leiognathus dussumieri* in the Gulf of Mannar. Annam and Dharmaraja (1981), studied the trends in the catch of silverbellies by mechanised boats in Tamilnadu during 1971-1975. James (1981), in his studies on the exploited and potential capture fishery resources in the inshore waters of India, described the silverbellies as contributing to the major commercial catches of Tamilnadu, Andhra Pradesh and Kerala, with heavy landings in the south east coast around Mandapam. James (1986) and Karthikeyan *et al.* (1989) made a detailed study of the fishery and biology of *L. jonesi* from the Palk Bay and Gulf of Mannar. Murty *et al,* (1992) studied the fishery and stock assessment of silverbellies along the Tamilnadu and Andhra Pradesh coasts. The other works on silverbellies from other areas along the east coast , are that of Murty (1983, 1986a,1990) from the Andhra coast and Murty (1986b) from the West Bengal coast. The only work on the fishery of silverbellies along the Kerala coast is from the Calicut coast, four decades ago by Balan (1963).

It is clear that the landings and species composition of silverbellies from Kerala have not been documented so far. The present work attempts to fulfil this.

## MARINE FISHERIES OF KERALA

Located in the southern part of peninsular India, Kerala has a narrow stretch of land with a long surf beaten coast on the western side. It has a rich tradition in fisheries and with its long coastline of 590 kilometres, enjoys one of the world's most productive seas bordering it and contributes to an annual average of 25.7 % (data taken for thirty years from 1969-1999) of the annual marine fish landings of the country. The shelf waters of Kerala are greatly influenced by both the south-west and north-east monsoons and the subsequent upwelling and environmental changes strongly influence the spatial and seasonal distribution of the marine life in the coastal waters. Another notable feature of the marine fisheries of Kerala is the formation of annual mudbanks , which facilitate easy fishing operations by the country crafts. The monsoon fisheries of the mudbanks are composed of about fifty species of fishes and six species of prawns (Regunathan *et al.*, 1984).

During the past thirty years the marine fish production in Kerala has increased from 2.95 lakh tonnes in 1969 to 5.8 lakh tonnes in 1999, showing a gradual and steady increase with minor fluctuations in between, and with peak years in 1990 (6.63 lakh t). During this period the percentage contribution of the state to the total marine fish production of the country decreased from 32.2 % in 1969 to 24 % in 1999, with the highest contributions being in the years 1971 (38.4 %) and 1973 (36.7 %). Mechanisation was introduced in the state in the mid fifties. The introduction of trawlers in the inshore fisheries, the motorisation of traditional and artisanal craft in the eighties and the introduction of ring-seines in the late eighties were some of the technological advancements contributing to the substantial increase of fish production in Kerala during the past three decades.

The marine fisheries of Kerala were studied by several workers. Some important works include that of Nair (1953), Seshappa and Bhimachar (1955), Sam Bennet (1967), George *et.al.,* (1968), Antony Raja (1969), Banerji and Chakraborty (1970), Nair *et al.,* (1970), James (1972), Balan ( 1973, 1978, 1980, 1984), Silas *et.al.,* (1976), Mahadevan Pillai (1978), Luther (1979), and Shanmughavelu and Pillai (1980).

There are about 220 landing centres in the state (Jacob *et al.,* 1987). Apart from the two major fishing harbours at Cochin and Sakthikulangara , there are a number of centres; Munambam, Azhikal, Ponnani, Beypore, where mechanised boats land. There are 304 fishing villages/hamlets along the nine coastal districts of Trivandrum, Quilon , Alleppey, Ernakulam, Trichur, Malappuram, Calicut, Cannanore and Kasargode (Jacob *et al.,* 1987).

## SILVERBELLY FISHERY OF KERALA

Kerala ranks second in the country being next to Tamilnadu in silverbelly landings. The silverbelly landings of Kerala constituted on an average 1.54 % of the total marine fish landings of the state, during the 30 year period from 1969 to 1999. The total silverbelly catch of Kerala declined from 14019 tonnes in 1969 to 6154 tonnes in 1999 with years of peak abundance in 1973 (18392 tonnes) and 1974 (15523 tonnes), when they contributed 38.2% and 34.2 % respectively to the total silverbelly landings of India. The total catch of silverbellies in Kerala was 5118 tonnes in 1998 and 6154 tonnes in 1999.

Among the nine coastal districts of Kerala, Quilon stood first in the silverbelly landings , accounting for 46.48 % of the silverbelly catch of the state during the 1998-1999 period, with Calicut contributing to 20.93 % and Alleppey coming third with 8.87 %. The contribution of different coastal districts to the silverbelly landings of Kerala are shown (Figure 96).

The mechanised sector, consisting of the trawls, contributed to 51.6 % of the silverbelly landings of the state for the two year period from 1998-1999, while the motorised sector consisting of outboard trawl net, boat-seine , ring-seine and disco net, contributed to 33.9 % of the landings. The contribution of the artisanal sector with its non mechanised bottom set gill nets and drift gill nets, shore seines and boat seines was 14.49 %. Though the trawl nets dominated the catches, the proportion of the catch taken by the different gears in different districts show variations.

Among the different gears like trawls, gillnets, boat seines, ring seines, shore seines and disco nets in which silverbellies are caught in the state, trawls

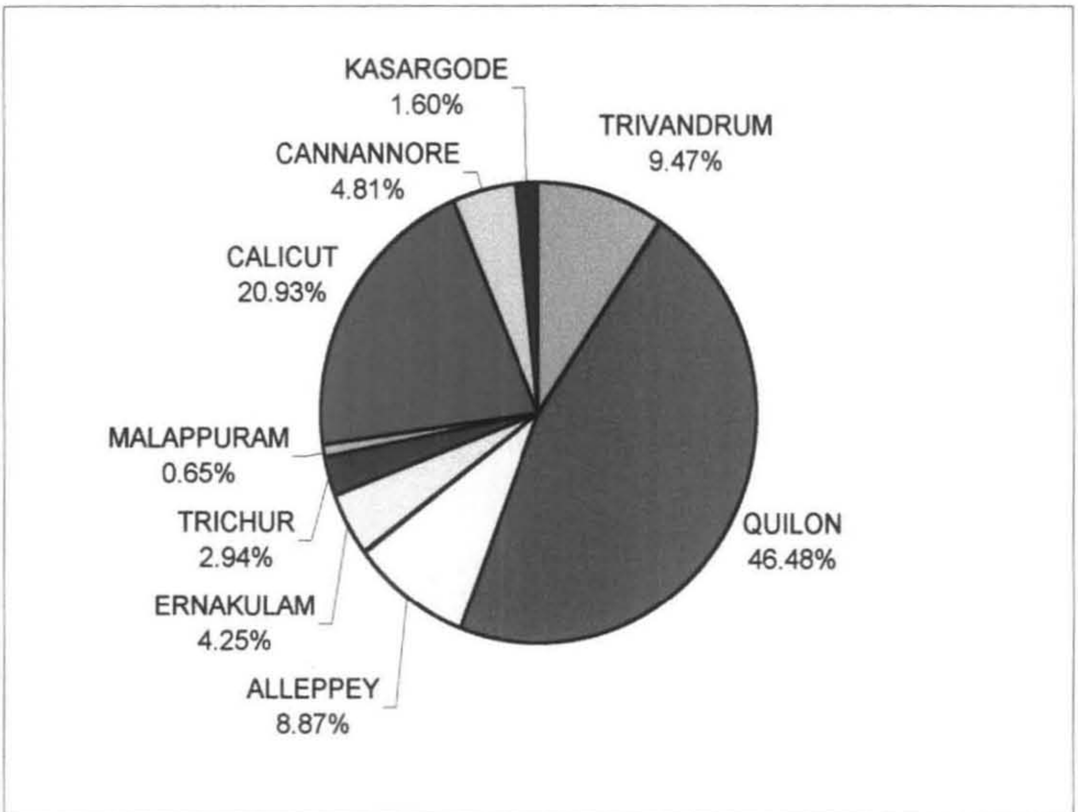



Fig. 96: Contribution of the different coastal districts to the silverbelly catch of Kerala during 1998-1999.

contributed to 53.36 % of the silverbelly catch during the 1998-1999 period. The contribution by different gears to the same are shown in the figure. (Figure 97).

While the pre-dominance of trawls in the silverbelly fishery of Kerala was the most notable feature of the gearwise analysis of silverbelly landings, it was conspicuous by its complete absence in Trivandrum district. Except Trivandrum , trawls dominated the silverbelly landings in all the other districts except Calicut , where the outboard ring-seine contributed to the majority of the silverbelly landings (48.1 %) , as compared to the trawl catches (44.7 %). In Quilon , Alleppey , Calicut , Cannannore and Kasargode , the outboard ring seines contributed to a sizeable part, being second only to the trawls, while in Ernakulam and Trichur, trawls were the major gear contributing to over 85 % of the silverbelly landings. All the other gears were only of minor importance with regard to the silverbelly fishery, barring the contribution of non mechanised drift gill net, (13.7 %) in Malappuram and outboard trawl net (9.7 %) , in Alleppey. The contribution of different gears to the silverbelly fishery in the different coastal districts of Kerala is shown (Figure 98).

Considering the district wise contribution of trawls to the silverbelly landings in the state, out of the total 5817 tonnes landed by this gear, Quilon contributed to 51.66 % followed by Calicut (18.14 %), and Ernakulam (7.58%).

## MATERIALS AND METHODS

The data were collected from the two major trawl landing centres of the state, Cochin Fisheries Harbour and Neendakara fisheries harbour for a period of twenty four months, from January 1998 to December 1999. The details of collection of data and analysis are mentioned in the earlier chapters.

## OBSERVATIONS

### *ESTIMATED LANDINGS OF SILVERBELLIES IN KERALA STATE*

The quarterly species composition estimates for Kerala state are obtained by raising the estimates of Cochin fisheries harbour and Neendakara fisheries harbour to the respective districts, Ernakulam and Quilon, separately pooling the estimates of the above districts, quarterly, and raising them to the estimated silverbelly catch of the Kerala state.

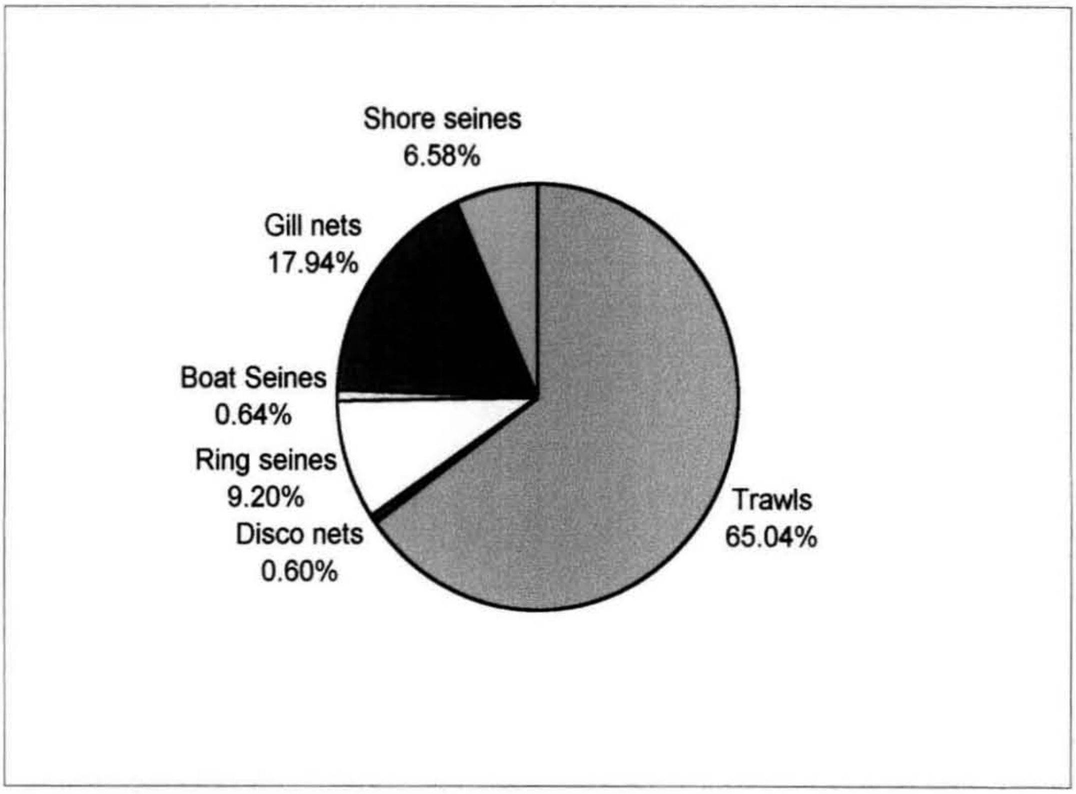



Fig. 97: Contribution of different gears to the silverbelly catch of Kerala during 1998-1999

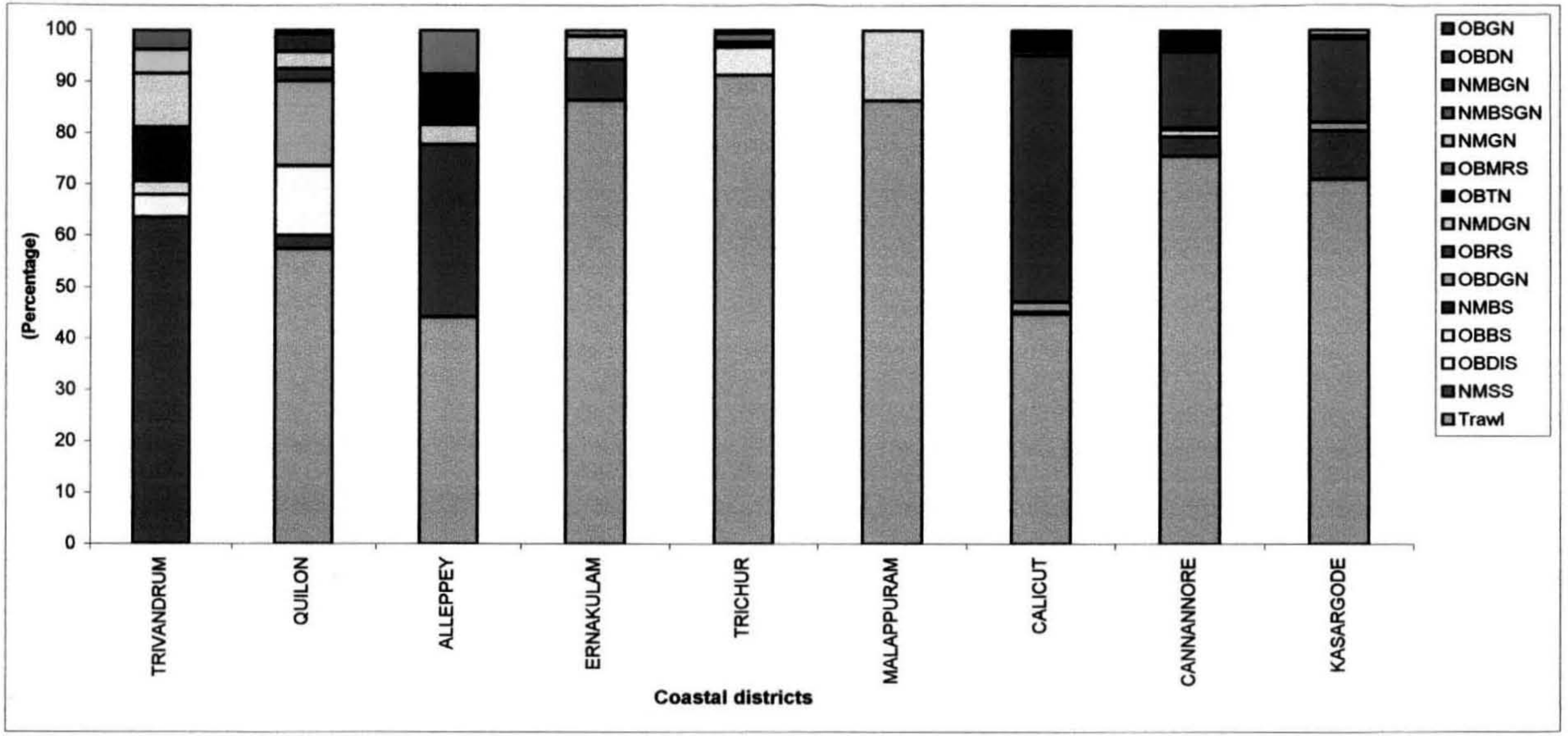



Fig. 98: Contribution of different gears to the silverbelly catch of the coastal districts of Kerala during 1998-1999

**OBGN**(outboard gillnet)**OBDN**(outboard driftnet)**NMBGN**(non-mechanised bottom gillnet)**NMBSGN**(non-mechanised boatseine and gillnet)
**NMGN**(non mechanised gillnet)**OBMRS**(outboard motorised ring seine)**OBTN**(outboard trawl net)
**NMDGN**(non mechanised drift gill net)**OBRS**(outboard ringseine)**OBDGN**(outboard drift gillnet)**NMBS**(non mechanised boatseine)
**OBBS**(outboard boatseine)**OBDIS**(outboard disco net)**NMSS**(non mechanised shoreseine)

During the 1998-1999 period, out of the 479 tonnes of silverbellies landed in Ernakulam district, 86.43 % was contributed by the trawls, while in Quilon district, 57.35 % of the total quantity of 5240 tonnes landed during the same period were contributed by the trawls.

During both years, the peak season of silverbelly landings were the first two quarters of the year, which contributed to over 70 % of the landings for the whole year. The leanest period was during the third quarter which coincides with the monsoon trawling ban and the two months immediately following the ban.

*SPECIES COMPOSITION*

Only thirteen species of silverbellies are landed in the commercial catches, while the other three (*L. fasciatus, L.smithhursti and L.elongatus )* are only of stray occurrence. The silverbelly landings of Kerala state are dominated by *L. splendens*, contributing to 47.27 % of the landings, followed by *S. insidiator* (24.46 %) and *L. brevirostris* (8.72 %). The estimated species composition of the silverbellies landed by trawls in Kerala for the period 1998-1999 is shown (Figure 99). It can be seen that only seven species figure prominently in the fishery contributing to over 98 % of the catches. The estimated catch of each species in different quarters of the year are shown in the (Figures 100&101). The third quarter is not represented well since it corresponds to the period of the trawling ban.

*CATCH PER UNIT EFFORT*

The trawl landings of Kerala in 1998 for silverbellies had an average catch per unit effort of 5.24 kg , with a maximum of 6.55 kg during the first quarter of the year and a minimum of 0.52 kg in the third quarter. The maximum catch per unit effort of 10.89 kg was recorded in Alleppey , followed by Quilon (10.89 kg) ,and Calicut (6.02 kg). The minimum of 1.07 kg was recorded in Malappuram, while Ernakulam recorded a catch per unit effort of 1.65 kg.

During 1999, the annual trawl landings recorded an average monthly catch per unit effort of 5.55 kg, with a maximum of 6.8 kg in the first quarter and a minimum of 2.61 kg in the third quarter. The maximum catch per unit effort of 12.37 kg was recorded in Quilon, followed by Calicut (4.45 kg) and Ernakulam (4.35 kg). The minimum catch per unit effort of 0.51 kg was again recorded in Malappuram.

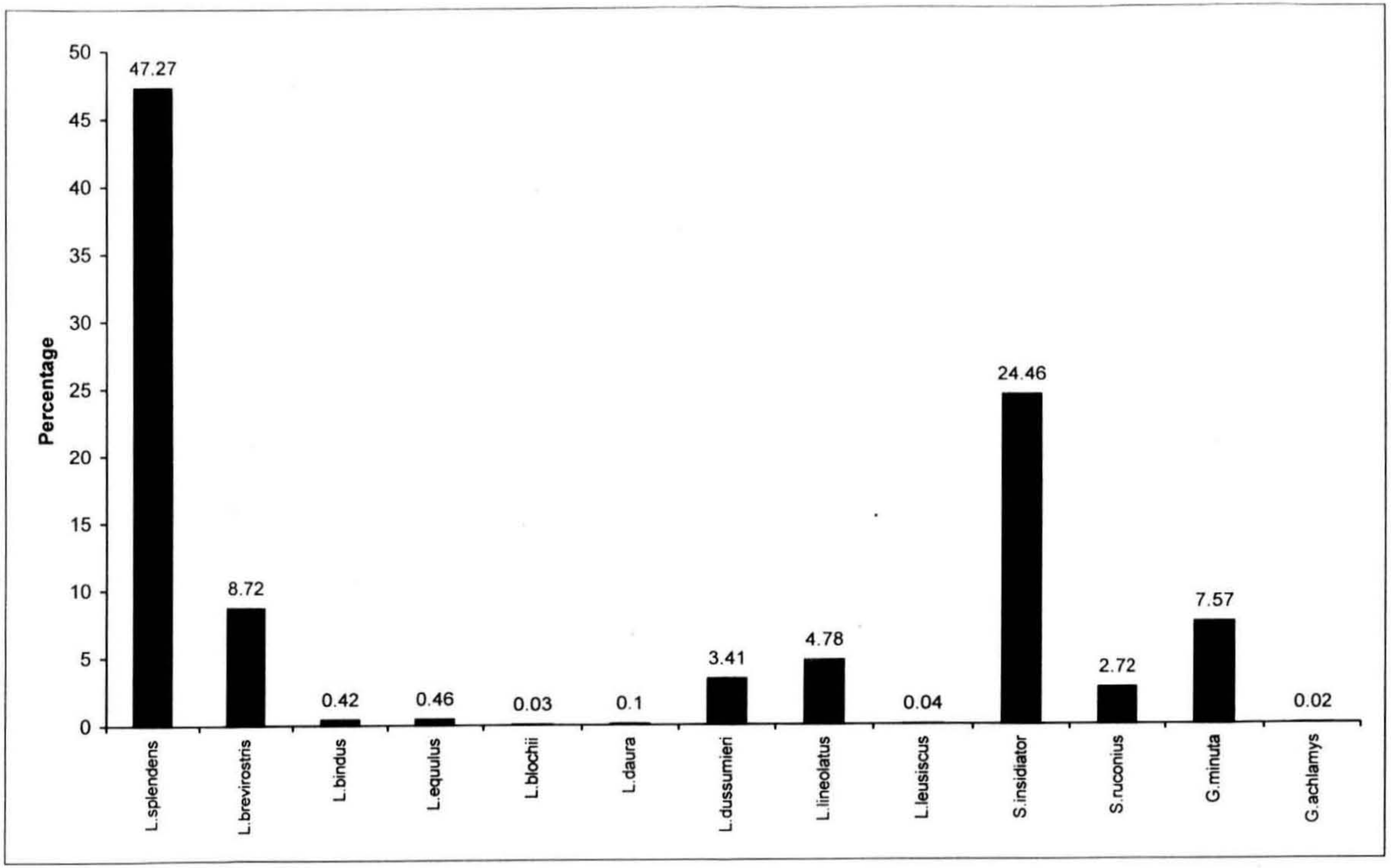



Fig. 99 Estimated Species composition (Percentage) of silverbellies of Kerala during 1998-1999.

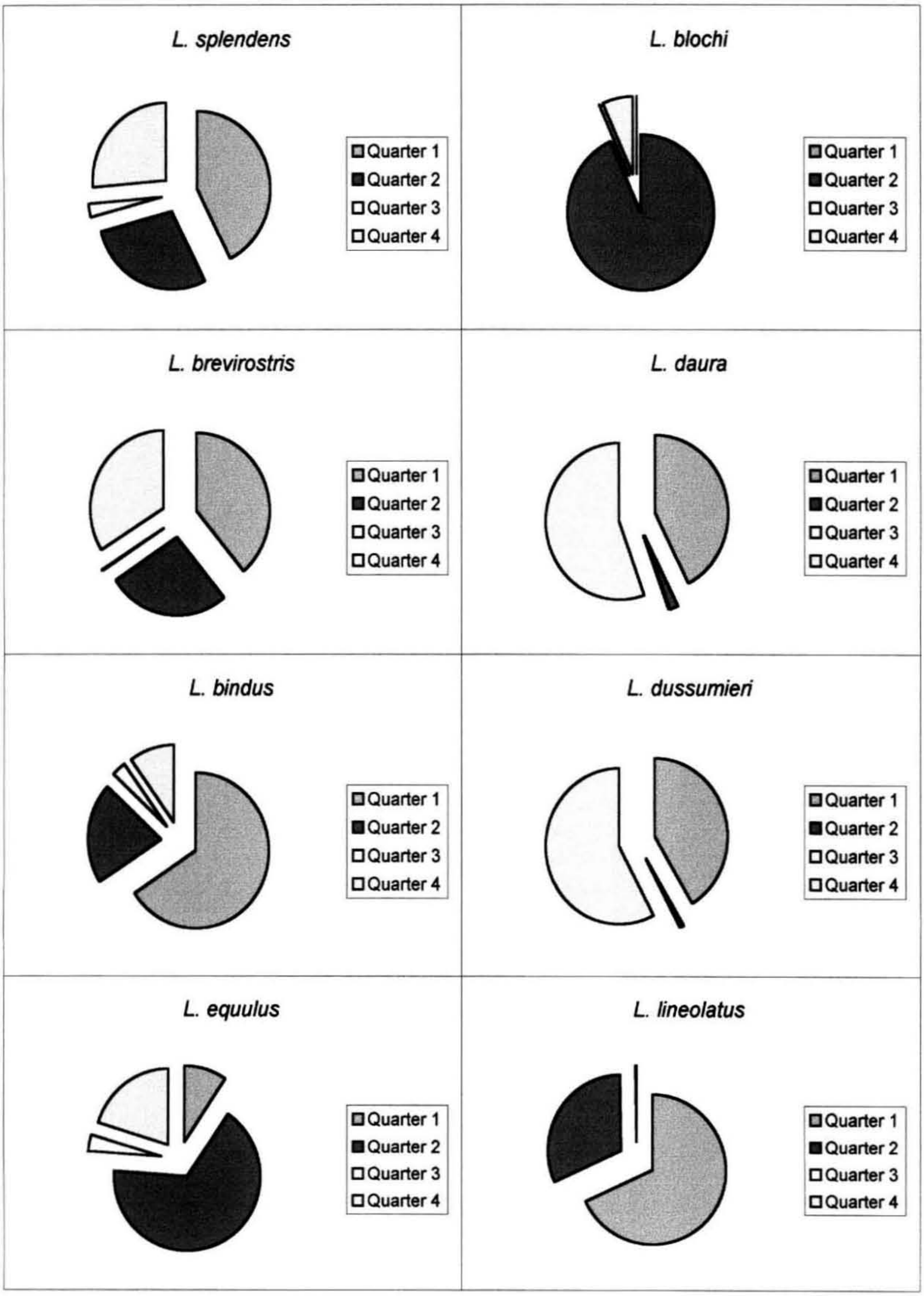



Fig. 100 Estimated catch of different species of silverbellies in different quarters in Kerala during 1998-1999

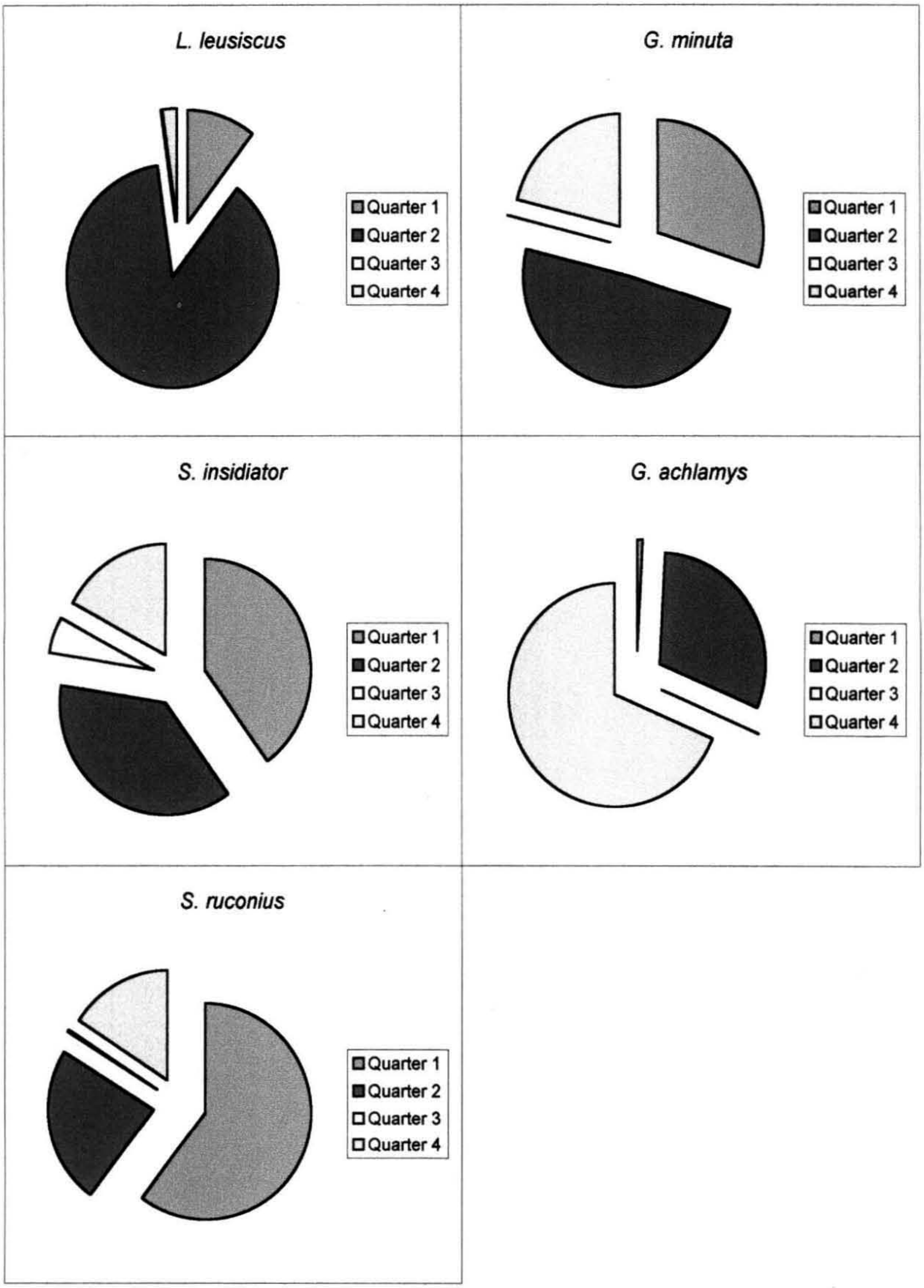



Fig. 101 Estimated catch of different species of silverbellies in different quarters in Kerala during 1998-1999

## REMARKS

Silverbellies are known to have a varied distribution throughout both the coasts with different species dominating the fishery along the different regions. Of the 21 species of silverbellies known to occur in the Indian seas, most of them occur in varying proportions in the Palk Bay and Gulf of Mannar along southern Tamilnadu coast. Off the coast of Andhra Pradesh and Northern Tamilnadu 9-12 species contribute to the fishery (Murty *et al.,* 1992) while in Kerala about four species (*Leiognathus splendens, L. brevirostris, Secutor insidiator* and *G . minuta*) contribute to the fishery.

The major species contributing to the fishery along Southern Tamilnadu are *Leiognathus jonesi, L.dussumieri* and *L.brevirostris* (James, 1973b, Murty *et al.,* 1992). Along Northern Tamilnadu and Andhra Pradesh, *L. bindus* and *Secutor insidiator* are dominant (Murty *et al.,* 1992). *L. bindus* is dominant along West Bengal (Murty, 1986b). *L. bindus* dominates the silverbelly landings at Madras and *S. insidiator* and *L. bindus* in Gujarat and Karnataka.

*Leiognathus splendens* is the most widely distributed species along the Indian coast (James, 1973 b), though it has not yet been reported to dominate the landings in any region. *L. bindus* was reported to dominate the trawl landings at Cochin (CMFRI, 1997a); however *L. splendens* dominated the silverbelly catch at Cochin during both years of the study period, contributing to nearly seventy percent of the silverbelly landings at Cochin. In the present study this species constituted the major component dominating in the leiognathid fishery in Kerala, contributing to nearly fifty percent of the silverbelly landings of the state.

Nearly ninety percent of the silverbelly landings of the state are contributed by the four species mentioned above (viz ., *L. splendens, L. brevirostris, S. insidiator* and *G.minuta*) . The rest is contributed by *L.bindus, L. equulus, L. blochi, L. daura, L. dussumieri, L. lineolatus,* and *S.ruconius. L. fasciatus* , *L. smithhursti* , *L. leuciscus* , *L. elongatus* and *G.achlamys* do not contribute significantly to the fishery.

The variations observed in species composition along different regions of the country have also been observed along Kerala in the present study. There was virtually no information on the peak periods of abundance of the different species of silverbellies along the Kerala coast. The present study has contributed towards this knowledge . The present study has also reported 5 species (*Leiognathus smithhursti, L. leuciscus, L.elongatus, L.blochi* and *G.achlamys)* for the first time from off Kerala.

The peak period of abundance of silverbellies differ along the various regions of the coast. Rao (1973) studied the distribution pattern of silverbellies in India and found *Leiognathus splendens* to be the dominant species and the peak season for silverbelly landings to be from July to September in Kerala. But from the present study it is clearly evident that the maximum landings for silverbellies (about 40 %) are during the first quarter of the year in Kerala.

The various gears used for the exploitation of silverbellies varies from the catamarans to trawlers with even little quantities being caught by the purse seiners as has been observed during the present study. In Kerala, as mentioned earlier, trawls are the major gear in the exploitation of silverbellies and fishing is mostly in the 30-35 m depth range. In the present study it was observed that the exploitation of siverbellies is mainly by the demersal shrimp trawls, having cod end mesh size of 18-22 mm, and operating in the near shore waters.

## UTILISATION

Silverbellies, being thin and lean fish with little flesh and many bones, are not considered wholesome table fish, although they are consumed in fresh state to a small extent, while the major part is utilised for the manufacture of high quality fish meal. A part of the landings at Mandapam go to fish meal plants and the remaining catches are sun dried after salt curing overnight. A part of the sun dried fishes (Plate: 4) are sent to interior markets for human consumption and a part is utilised for poultry and cattle feed. These fishes are suitable for conversion as nutritive fish powder and excess catches can be profitably converted into fish meal and fertiliser, and used in agriculture and livestock development (James 1973b).

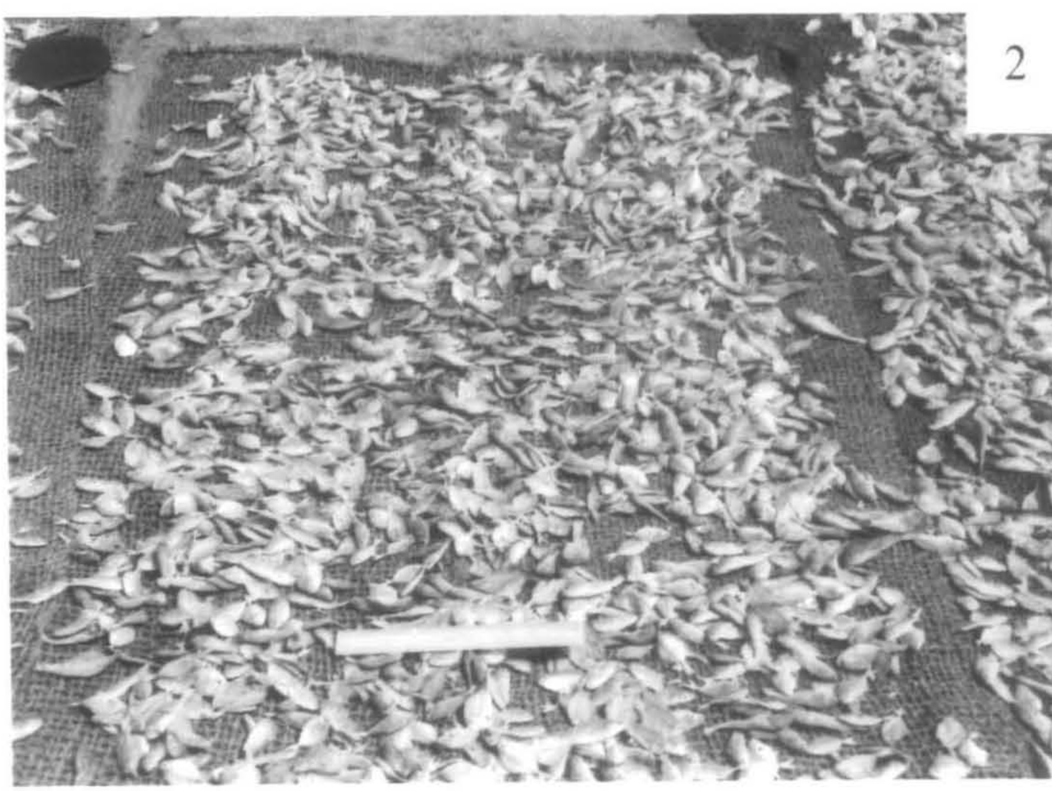
Plate 4

1. Catch of silverbellies at Cochin Fisheries Harbour

2. Sun-drying of silverbellies at Neendakara Fisheries Harbour

Plate 4

1



2

# Summary

## SUMMARY


A review of literature on the fishes of the family Leiognathidae from India revealed that there is no scientific database on these resources from off Kerala except one brief report on one species and another brief study from the Vembanad lake (Cochin, backwaters). The present study was hence taken up to study the taxonomy, biology and population dynamics of these resources on the basis of the data generated during the two years 1998 and 1999. Two major fish landings centres (Cochin Fisheries Harbour and Neendakara Fisheries Harbour) in Kerala have been chosen for collection of material and data.

A total of 16 species of the family Leiognathidae have been collected from the commercial landings and detailed biometric data collected and the species defined with the help of adequate descriptions. Various relationships in the morphometric characteristics have been studied and regression equations fitted to enable comparison of the populations of these species from Kerala with those from other regions. Of the 16 species collected and described in the present work, five species are reported for the first time not only from Kerala coast but from the entire west coast of India.

The reproductive biology has been studied on the basis of data of 2112 specimens of *Leiognathus splendens* and 1546 specimens of *Secutor insidiator* collected over a period of 14 months from October 1998. It has been shown: a) the scale of maturation stages as adapted by earlier workers is not adequate and therefore a reliable scheme of maturation stages has been developed (for the first time for any Indian marine fish) and applied in the present study. b) A critical analysis of the data on the ova diameter frequency distribution of *L. splendens* and the frequency distribution of different stages of maturation in different length groups and months in *L. splendens* and *S. insidiator* has been made and it has been shown that spawning takes place in batches regularly at certain intervals once the juveniles undergo the process

of maturation and reach ripe stage. The spawning takes place almost round the year c) After a critical evaluation, it has been shown that length at first maturity needs to be estimated with the data pertaining to a short period when the catches consist of large number of mature and gravid fishes so as to eliminate the possibility of growth in length affecting the estimate of length at first maturity.

A review of methods available for study of growth has been made and limitations/bottlenecks brought out. In the case of ELEFAN method, which has been followed in the present work also, the issues confronted are brought out and the manner in which real growth parameters that describe the growth of the population could be extracted, explained. The study was carried out in five species on the basis of large representative samples collected for 24 months from January 1998. the estimated values are : L. splendens $L\infty=140$, $K=0.86$; S. insidiator $L\infty = 130, K=0.80$; S. ruconius $L\infty = 92$, $K = 1.19$ and G. minuta $L\infty = 160$, $K=1.7$.

The various mortality rates have been estimated in respect of five species and the estimates compared with similar estimates from other localities. The Beverton-Holt yield per recruit analysis was made in all the five species and the $F_{max}$ (F corresponding to maximum Yw/R) under the current tc and tcmax ($t_c$ corresponding to max Yw/R) under the current F have been determined and the status of each of the species stocks brought out. In all the five species the Fmax is shown to be less than the present F and the current age at first capture is less than the value that leads to increase yields.

Mixed fisheries assessment has been carried out in five species, (they constitute about 90% by weight of silverbelly landing) and the maximum equilibrium yield that could be taken determined. The analysis revealed that maximum equilibrium yield could be obtained at 25% of present effort.

It has been shown that maximum equilibrium yield could be achieved at 25% of current fishing effort level and the current tc. Similarly it has been shown that maximum equilibrium yield of silverbellies could be obtained at 200% of the current cod end mesh size keeping the current effort constant.

It has been suggested that the assessment of the type that is conducted in present study, needs to be conducted in all other exploited species stocks to be able to determine the level of fishing effort and cod end mesh size of trawl for drawing up suitable management measures. The fishery of silverbelly along the Kerala coast has been described. The seasonal variation in abundance of different species has been recorded. It has been observed that the maximum landings are during the first quarter of the year.

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